SCHOOL OF CIVIL ENGINEERING

INDIANA DEPARTMENT OF HIGHWAYS

JOINT HIGHWAY RESEARCH PROJECT
JHRP-83-5

ENGINEERING SOILS MAP OF HAMILTON COUNTY, INDIANA

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FINAL REPORT

ENGINEERING SOILS MAP OF HAMILTON COUNTY, INDIANA

TO: H. L. Michael, Director
Joint Highway Research Project

May 4, 1983

Project: C-36-51B

FROM: Robert D. Miles

File: 1-5-2-69

Attached is the Final Report on the "Engineering Soils Map of Hamilton County, Indiana." The map and report have been produced by Mr. E. M. Gefell under the director of Professor Robert D. Miles.

This is the 68th county map to be completed. Mr. Gefell developed the soils map and the report using aerial photographs in conjunction with available literature. The map and report show and discuss the areal distribution of the various land forms and parent materials within Hamilton County. The report is very useful in planning and developing engineering facilities and highways in Hamilton County.

The Report is presented to the Board as showing completion of the Hamilton County engineering soils mapping project.

Sincerely,

Robert D. Miles

Robert D. Miles

RDM:rw

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Final Report

ENGINEERING SOILS MAP OF HAMILTON COUNTY, INDIANA

by

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Joint Highway Research Project

Project No.: C-36-51B
File No.: 1-5-2-69

Prepared as Part of an Investigation

Conducted by

Joint Highway Research Project
Engineering Experiment Station
Purdue University

In Cooperation with

Indiana Department of Highways

Purdue University
West Lafayette, Indiana
May 4, 1983

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All airphotos used in connection with the preparation of this report automatically carry the following credit line: photographed for Commodity Stabilization Service, Performance and Aerial Photography Division; United States Department of Agriculture.

Engineering Soils Map of Hamilton County, Indiana

Introduction

The Engineering Soils Map of Hamilton County, Indiana, (see Figure 1), which accompanies this report was prepared primarily from 1941 aerial photography using accepted principles of interpretation (1)*. A photomosaic was assembled of the area and the land form - parent material associations delineated through stereoscopic inspection, (a 1957 index photomosaic of Hamilton County is shown in Figure 2). The photographs had an approximate scale of 1:20,000 and were purchased from the United States Department of Agriculture.

Extensive use was made of the Agricultural Soil Survey of Hamilton County (2) as a cross-reference to check soil boundaries. The pedalogical soil series were grouped according to parent material and delineated on the agricultural map sheets using a color code. These areas were then found on the photomosaic and modification of soil boundaries made where evidence found with re-examination of the airphotos warranted it. The agricultural map was particularly useful in locating sand and gravel deposits, areas of peat and muck, and gravel pits and ponds not present on the 1941 aerial photographs.

Several field trips were taken to the county to verify the soil boundaries and resolve ambiguous details. Many samples were

* note: numbers in parenthesis footnote references.

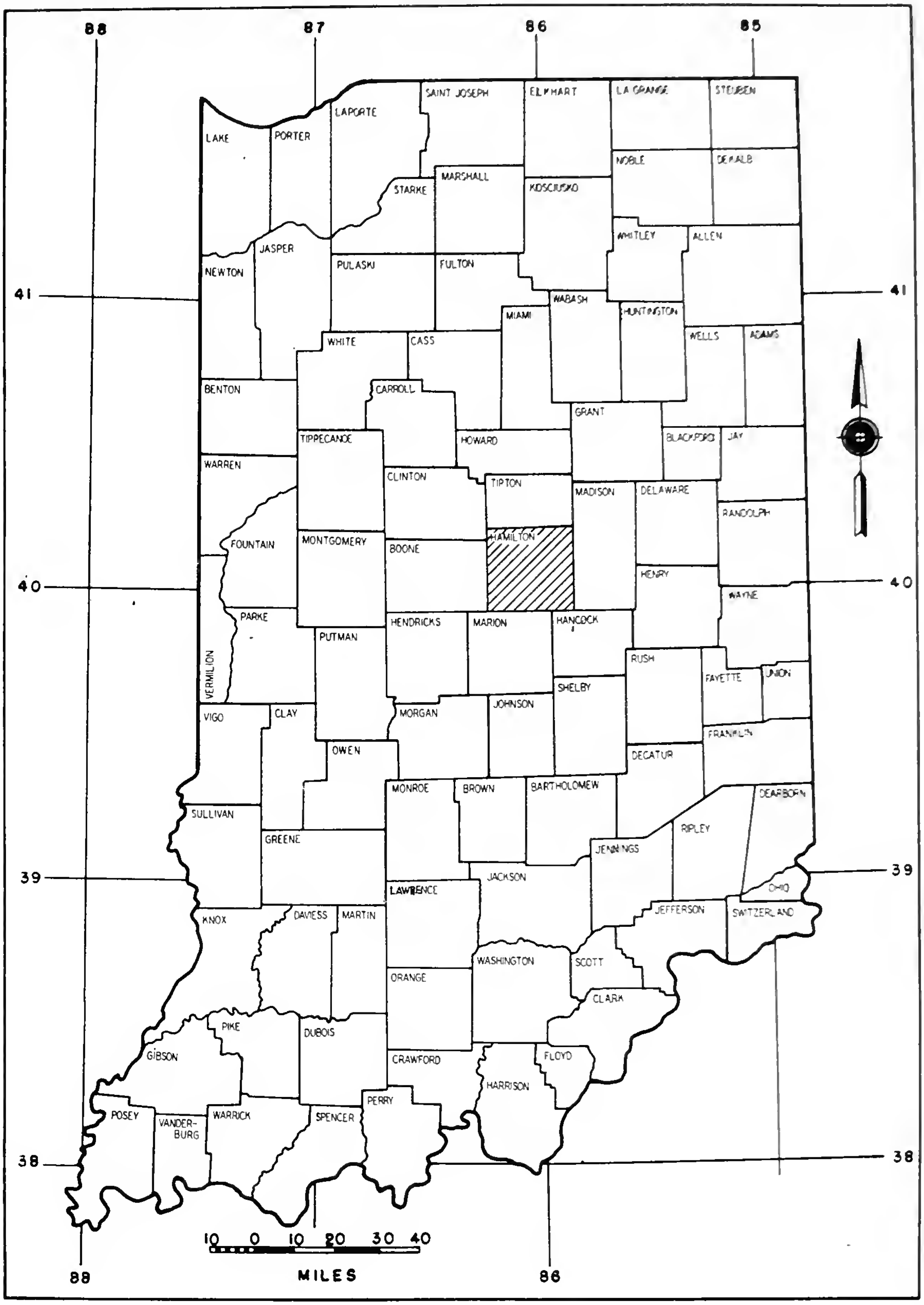


FIGURE 1. MAP OF INDIANA SHOWING LOCATION OF HAMILTON COUNTY

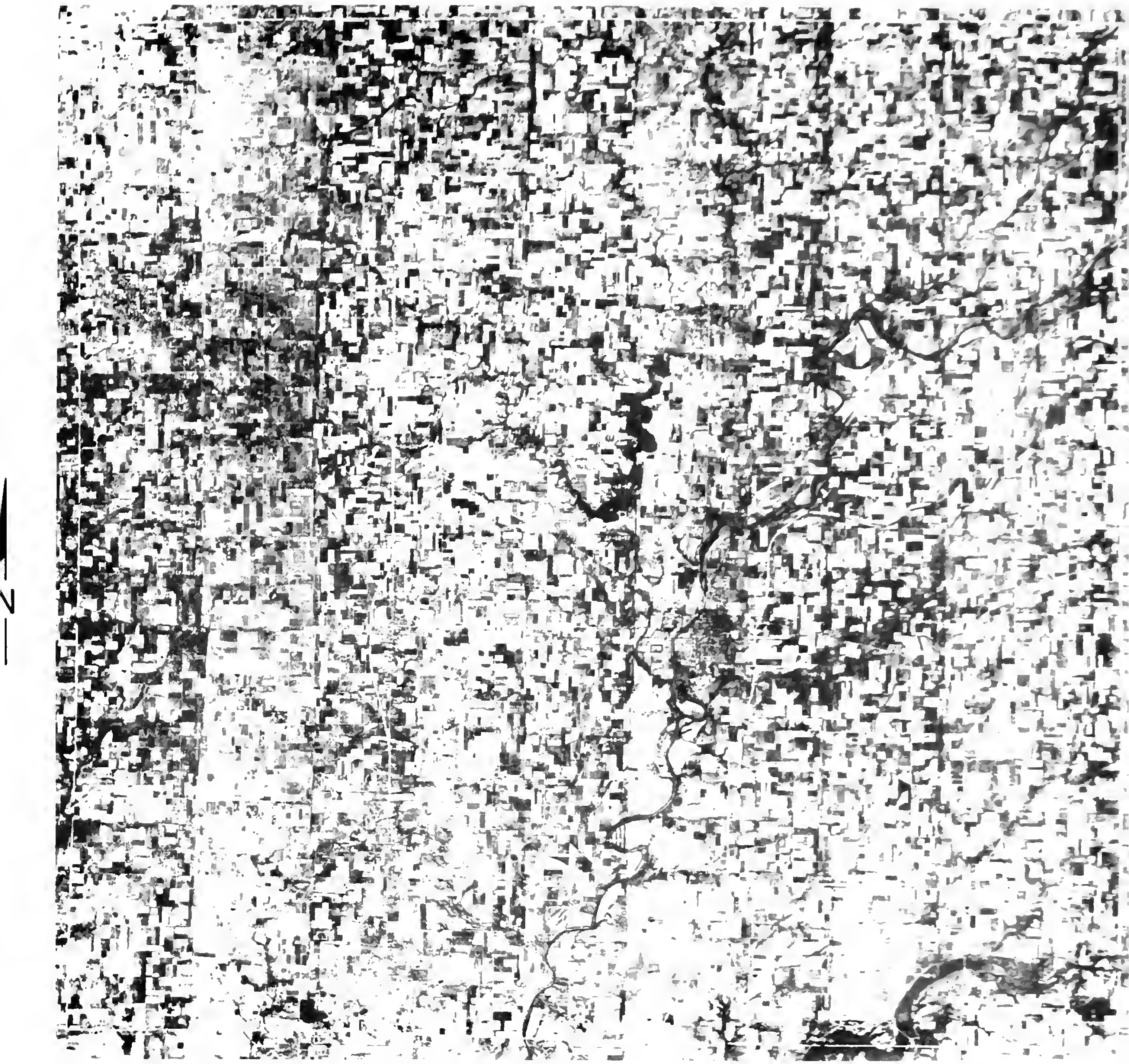


FIGURE 2. PHOTOMOSAIC OF HAMILTON COUNTY

taken, extending to a depth of approximately 4.5 feet in order to correlate near-surface texture with aerial photographic patterns. The results of the field sampling also supplemented roadway and Agricultural Soil Survey borehole information in preparing the general soil profiles shown on the left-hand side of the engineering soils map.

The Engineering Soils Map of Hamilton County was part of an on-going effort to complete a comprehensive and contiguous engineering soils survey of the State of Indiana using a standard set of symbols developed by the Airphoto Interpretation Laboratory, School of Civil Engineering, Purdue University. Boundaries of map units in any given county were to correlate with the soil boundaries of all adjacent counties. In the process of airphoto interpretation, some subjective disagreements may occur as to the nature of a given soil unit and the location of its boundaries. Where this author was not in total agreement with others of adjacent counties, an attempt was made to close off a disputed map unit within Hamilton County without losing the continuity of the land form pattern percieved by the other author. In some instances, these areas were terminated abruptly, very near to the Hamilton County Line. Most of the disputed areas were controversial due to a lack of adequate relief, (ie., commonly less than 5 feet), on which to base a judgement for boundary placements by stereocopic inspection, leaving photo tones and surface textural appearance, both subject to personal interpretation, as the primary criteria determining boundary locations.

The text of this report supplements the engineering soils map and includes a general description of the area as well as more detailed information about the various land form - parent material associations found within Hamilton County. The map itself shows the land form - parent material areas, soil textures, and generalized soil profiles. The engineering characteristics of the soils and borehole information may be found in appendixes in the back of this report.

Description of the Area

General

Hamilton County is located in central Indiana and is nearly a square with an area of 256,640 acres or 401 square miles (2). It is bounded to the north by Tipton County, to the east by Madison County, to the south by Hancock and Marion Counties, and to the west by Clinton and Boone Counties, (see Figure 1). Noblesville is the seat of county government and is located approximately twenty miles northwest of Indianapolis. Distances to other major urban areas in Indiana are shown in Figure 3.

Recent urban development had occurred in the southern and central parts of the county, particularly around Noblesville and Carmel. Subsequent transportation improvements included the addition of Interstates 465 and 69 in the mid-1960's as well as widening and upgrading of U. S. Highway 31. Much of the new urban development was associated with the northward sprawl of the

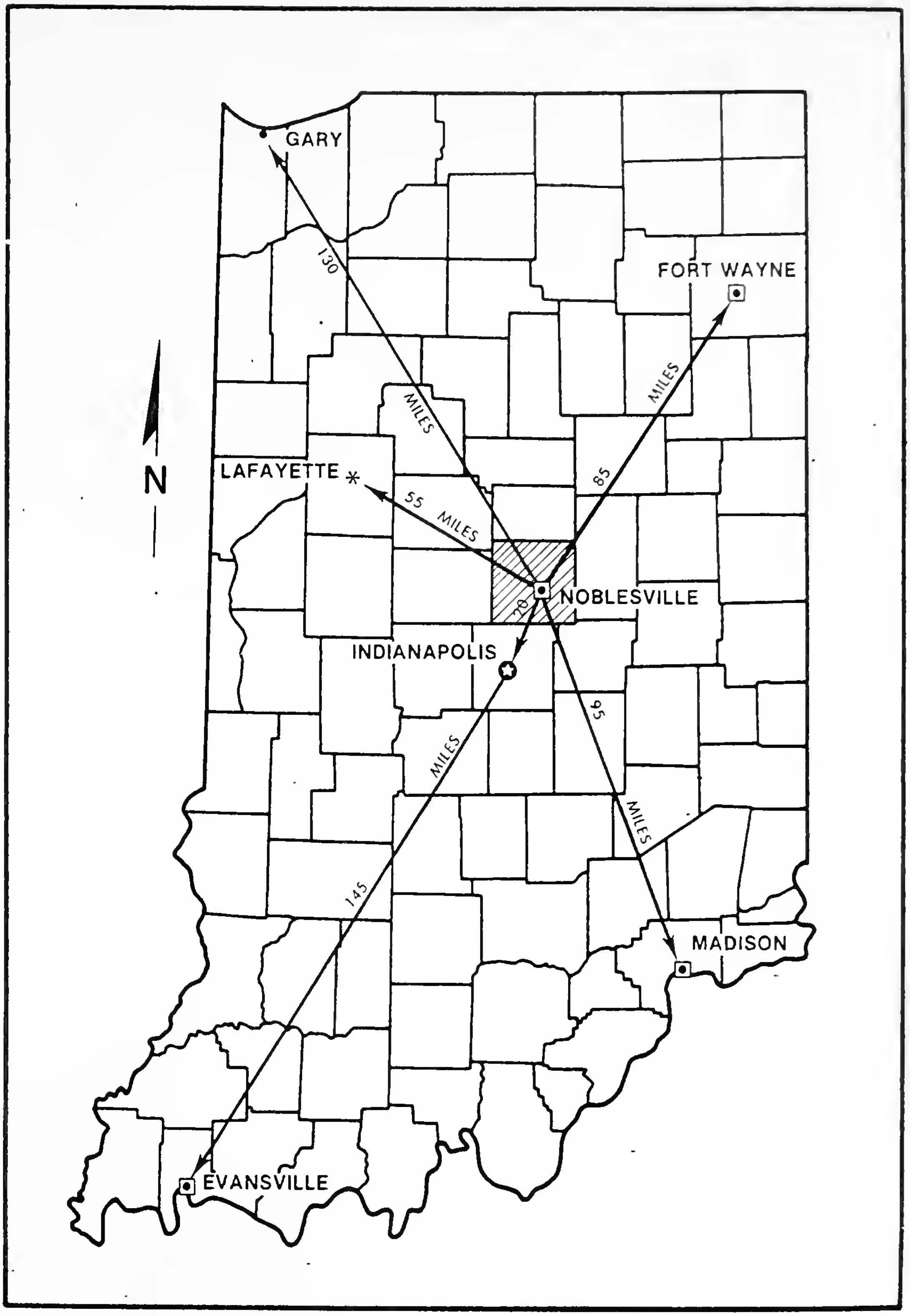


Figure 3. Map Showing Distance Between Noblesville and other Major Urban Areas in Indiana (2).

Indianapolis metropolitan area. Most of the new residents were employed by industries in Noblesville or in Indianapolis in nearby Marion County (2). Table 1 gives 1980 population data for townships, towns, and cities in Hamilton County.

Table 1. 1980 Population Data For Hamilton County. (3)

Township	1980 Population
Adams	4,307
Clay	32,606
Delaware	4,660
Fall Creek	2,757
Jackson	7,435
Noblesville	18,894
Washington	7,424
Wayne	1,898
White River	2,045
	82,097 total,
(rural population -	37,725)
Town/City	
Carmel	18,272
Cicero	2,557
Noblesville	12,056
Fishers	2,008
Westfield	2,783
Sheridan	2,200
Arcadia	1,801

The major farming activities in the county included the growing of cash grain crops and the raising of livestock. Much of the grain was purchased by processing plants in Indianapolis, while the livestock was marketed in surrounding counties (2). 1976 land use data for Hamilton County is summarized in Table 2.

Table 2. 1976 Land Use Data For Hamilton County. (4)

Land Use	Area (acres)
Urban	14,020
Agriculture	225,490
Forest	13,770
Water	2,130
Wetland	-
Barren	810
Unclassified	590
	256,640 total

Natural drainage was poor in places and artificial drainage was common. Two reservoirs were located in Hamilton County, (see Figure 2), which provided water for industrial and municipal use in southern Hamilton County and the Indianapolis metropolitan area. Geist Reservoir was located on Fall Creek in the southeast part of the county and Morse Reservoir was located on Cicero Creek in north-central Hamilton County (2). Most of the land area indicated as being covered by water in 1976 was under the West Fork White River and Geist and Morse Reservoirs.

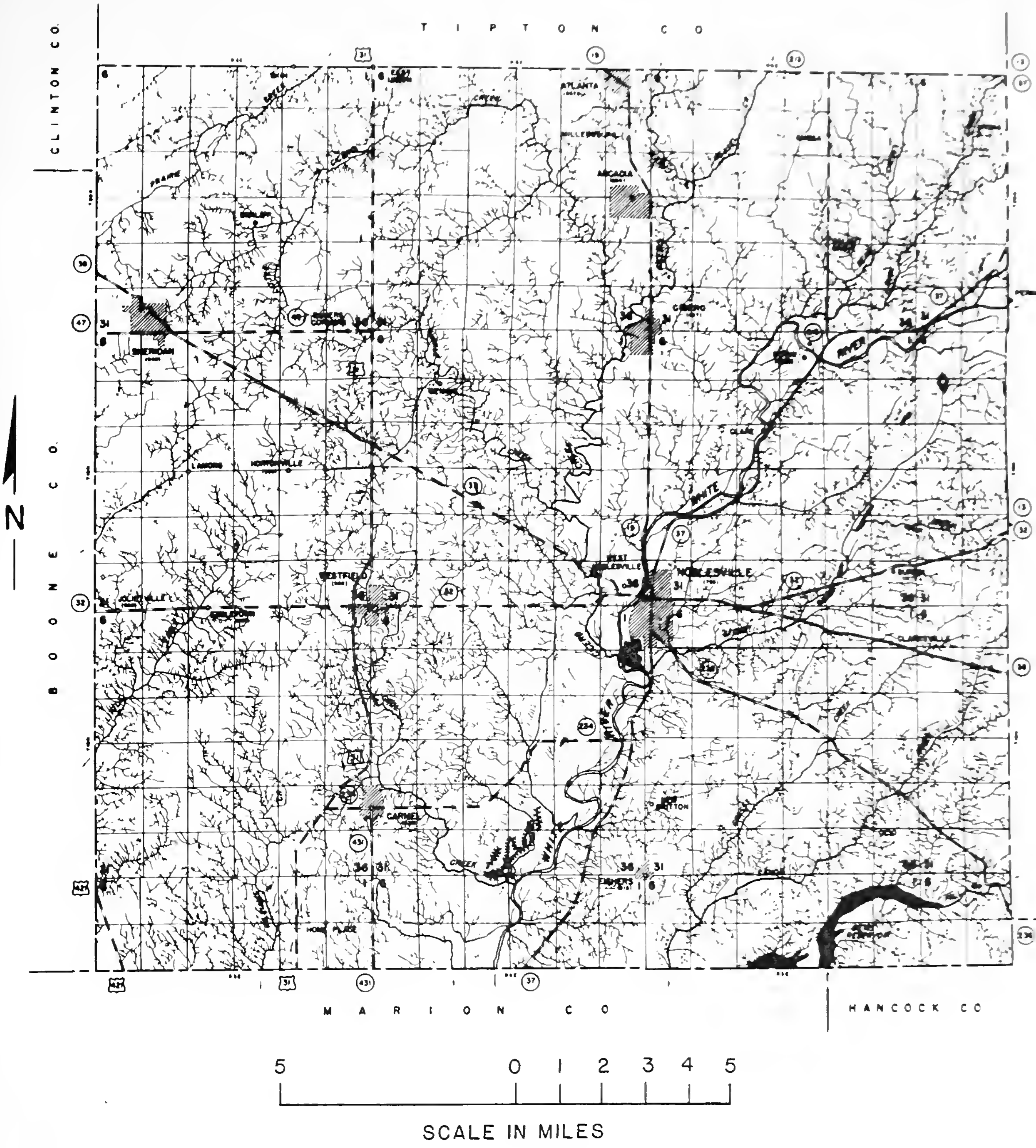
Drainage

Hamilton County was entirely within the White River drainage basin (5). The pattern of drainage was regionally dendritic and locally parallel to sub-parallel, with the water flowing toward the southwest (see Figure 4) (6). Drainage was best developed on the West Fork White River and its main tributaries, as erosion had effectively entrenched these streams in the ground and ridge moraine.

Some streams exhibited erratic behavior and may have been controlled by bedrock in places. Little Cicero Creek near Deming, Cicero Creek northwest of Noblesville and the West Fork White River near Strawtown indicated the possibility of such control. Limestone was known to outcrop along the West Fork White River near Strawtown and on Stoney Creek east of Noblesville (6).

Drainage in the eastern half of the county was still controlled to some extent by old glacial sluiceways. Drainage in the sluiceways was commonly intermittent and was aided in places by man-made trenches that straightened their former paths.

Small, closed drainage basins appeared in clusters and individually, particularly along the drainage divides. Most of these were small infiltration basins in relatively coarse sediment, while some were kettles or ice block depressions. A few of these depressions may have been the surface expression of shallow, till-covered sink holes in limestone bedrock. Such features found in areas where the overburden above limestone bedrock is



DRAINAGE MAP

FIGURE 4. HAMILTON COUNTY (6)

INDIANA

known to be only a matter of 10 feet or so are the most likely depressions to be associated with sink hole formation. Areas of concern include ground and ridge moraine near base level of the West Fork White River and its main tributaries where depth to bedrock is usually at a minimum.

Ridge moraine in the western third of the county disrupts the general flow of water to the southwest, resulting in the anomolous deflection of Little Cicero and Prairie Creeks to the northeast. Both creeks veer to the east and are eventually tributary to the southwest flowing Cicero Creek, Prairie Creek in Tipton County and Little Cicero Creek in north-central Hamilton County.

No natural lakes were found in Hamilton County, however, natural and man-made ponds did exist (6). The natural ponds were commonly associated with ice block depressions in the ridge and ground moraine, whereas the man- made ponds were usually for farming purposes or a result of previous or on-going gravel pit operations on glacial sluiceways and terraces. Geist and Morse reservoirs, located in Hamilton County as previously mentioned, provided water for industrial and municipal purposes for Hamilton County and the Indianapolis metropolitan area.

Climate

The climate of Hamilton County was humid and continental, and only marginally affected by the Great Lakes to the north. Cool air masses from Canada alternated with seasonally warm,

humid air from the south. These alternating cool and warm air masses promoted relatively large daily and seasonal temperature fluctuations within the county (2).

The average annual precipitation in the county was 37.2 inches, 58 percent of which fell from April through September. The heaviest one- day rainfall recorded in Noblesville before 1974 was five inches on September 2, 1926. An average of twenty-one inches of snow fell per year (2).

The average winter temperature was 29° F, while summer temperatures averaged about 72° F. The lowest temperature recorded in the county was -24° F on January 18, 1930, while the highest temperature recorded was 112° F in July, 1936 (2). These temperatures were recorded at the Whitestown weather station. Table 3 gives data on temperature and precipitation recorded at Whitestown and Noblesville respectively between 1941 and 1973.

Physiography

Hamilton County lies in the Till Plain Section of the Central Lowland Province of the United States. With respect to Indiana, it lies in the Tipton Till Plain Province (see Figure 5)(5).

Topography

The topography of Hamilton County, (see Figure 6), generally varied from gently undulating ground moraine to hummocky tracts of ridge moraine. Kames were found that stood 20-30 feet above

TABLE 3 CLIMATIC DATA FOR HAMILTON COUNTY, (1941-1973), (2).

[Data recorded at Whitestown (temperature) and Noblesville (precipitation)]

Month	Temperature				Precipitation				
			2 years in 10 will have at least 5 days with--			1 year in 10 will have--			
	Average daily maximum	Average daily minimum	Maximum temperature equal to or higher than--	Minimum temperature equal to or lower than--	Average monthly total	Less than--	More than--	Days with snow cover of 1 inch or more	Average depth of snow on days with snow cover of 1 inch or more
	°F	°F	°F	°F	In	In	In		In
January---	35	18	58	- 7	2.6	0.7	4.7	11	4.0
February--	39	21	59	- 1	2.2	0.6	3.7	7	2.8
March-----	49	29	72	10	3.1	1.4	5.9	2	2.6
April-----	63	41	81	24	4.0	1.6	7.0	(1/)	1.8
May-------	74	50	87	33	4.2	1.7	7.0	0	0
June------	83	59	93	44	4.1	1.8	6.6	0	0
July------	86	61	94	50	3.7	1.6	7.0	0	0
August----	84	59	93	46	2.9	1.4	5.4	0	0
September-	78	52	91	36	2.7	1.1	6.3	0	0
October---	66	42	82	26	2.4	0.8	4.2	0	0
November--	51	31	70	13	2.9	1.1	4.5	1	2.6
December--	38	21	60	0	2.4	0.8	5.7	7	3.1
Year---	62	40	96 2/	- 9 3/	37.2	30.9	46.9	28	3.3

1/ Less than 1/2 day.
2/ Average annual highest maximum.
3/ Average annual lowest minimum.

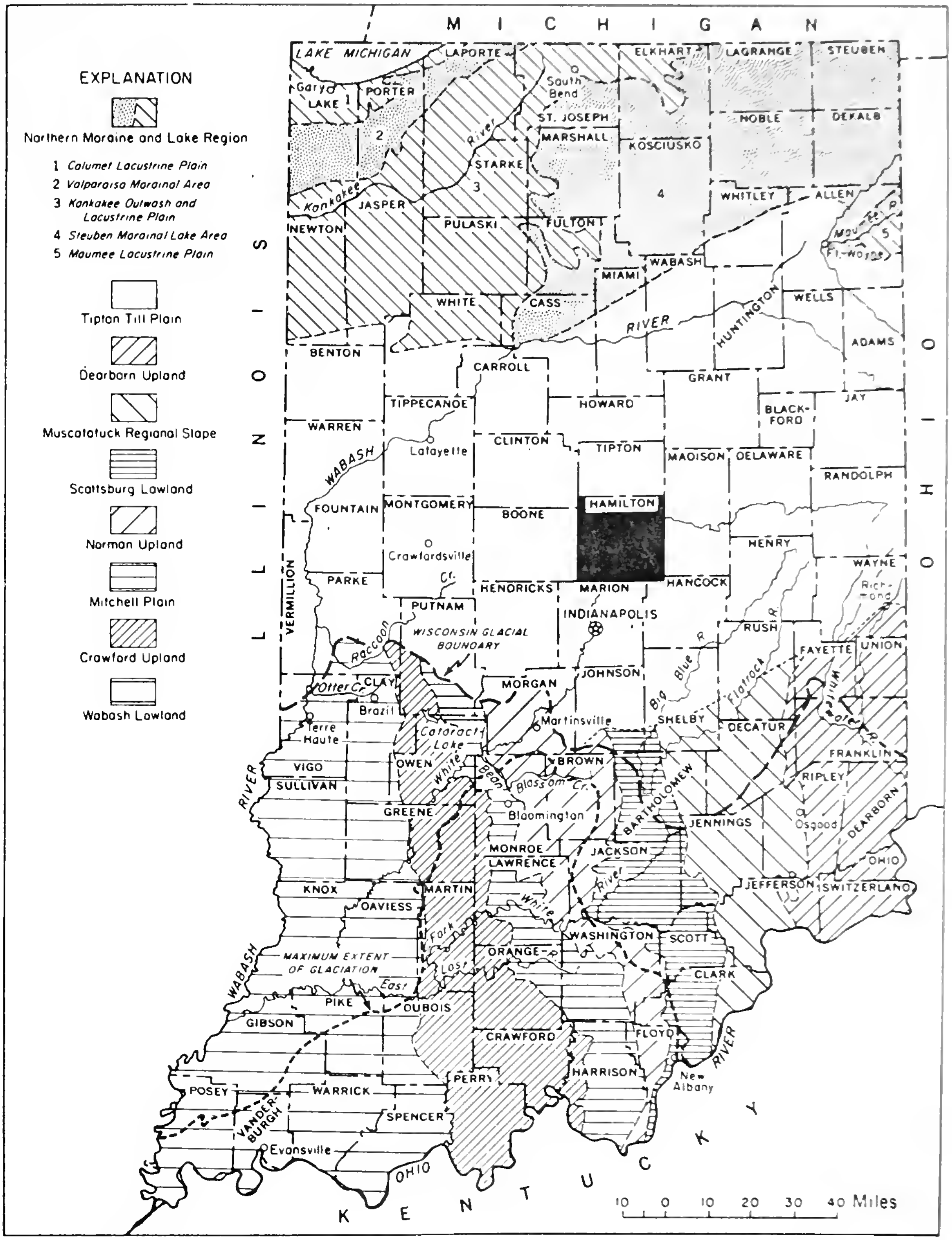


FIGURE 5. MAP OF INDIANA SHOWING PHYSIOGRAPHIC UNITS, GLACIAL BOUNDARIES AND LOCATION OF HAMILTON COUNTY. MODIFIED FROM INDIANA GEOL. SURVEY REPT. PROG. 7, FIG. 1.

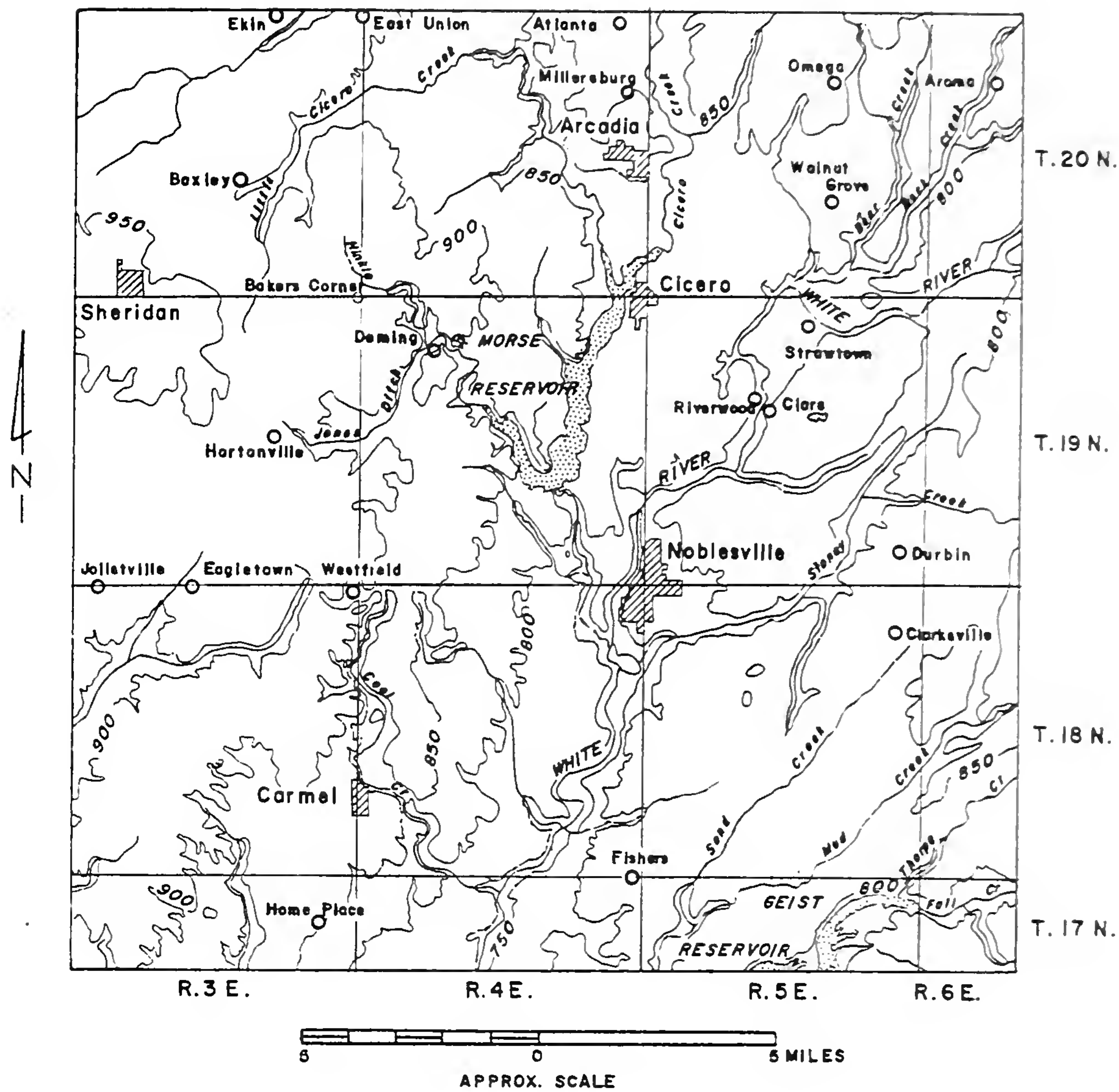


FIGURE 6. TOPOGRAPHIC MAP OF HAMILTON COUNTY
CONTOUR INTERVAL, 50 FEET

their surroundings, while the ground moriane was commonly broken by small, sandy knolls, 10 feet in height or less.

The greatest local relief was found in association with the degradational processes of the West Fork White River and its main tributaries and was as much as 85 feet in places (6). Areas of outwash terraces were gently rolling, marked by rather abrupt changes in elevation where old glacial meltwater channels were found. The topography of large glacial sluiceways in the eastern third of the county was similar to that of the outwash terraces which were located in bands generally a mile or more wide adjacent to the present course of the West Fork White River.

The highest point of elevation in Hamilton County was about 980 feet above sea level and was located in the northwestern part of the county about one mile northwest of the town of Sheridan (7) on top of a large kame. The lowest natural elevation, 725 feet above sea level, was found where the West Fork White River exits Hamilton County at the Marion County Line (see Figure 6). It was possible that the quarry operation near the Marion County Line about one mile west of the West Fork White River may have excavated below 725 feet above sea level. However, due to lack of information and the fact that it would be a small and man-made low point, the possibility was omitted in this report.

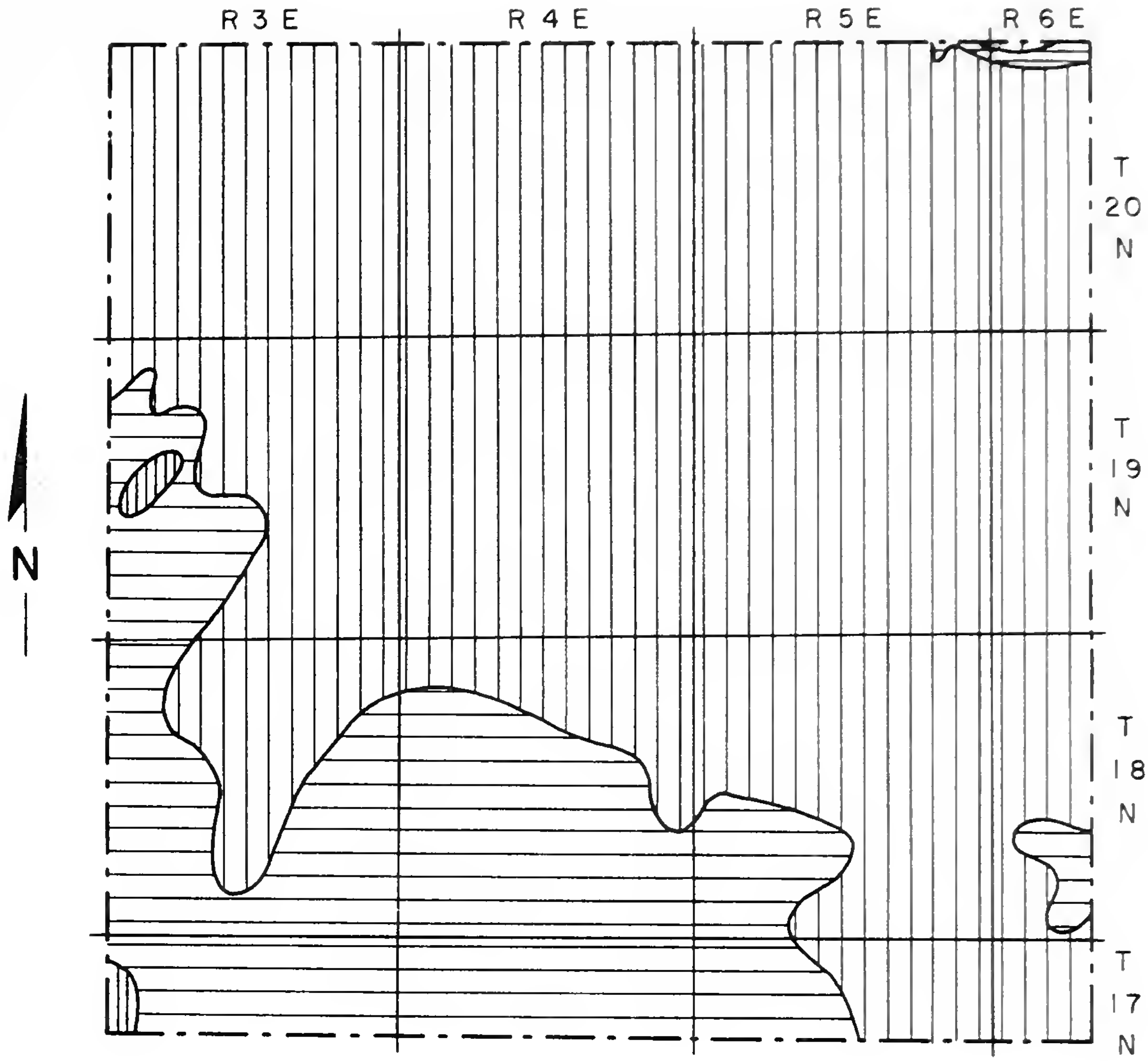
Bedrock Geology

The bedrock of Hamilton County consisted primarily of limestone and dolomite of Silurian and Devonian age (7). Two small

areas of Devonian and Mississippian age new Albany shale were found along the western county line. A small area of late Ordovician age shale and limestone was located in the northeast corner of the county (see Figure 7). The bedding dipped less than one degree to the west (7).

Glacial drift, generally varying in thickness from 30-350 feet, covered the bedrock in most places. The glacial drift cover was thinnest near the West Fork White River and its main tributaries to the east. Limestone bedrock outcropped along the West Fork White River near Clare and Strawtown, on Fall Creek above Geist Reservoir and on Stoney Creek east of Noblesville (6,8). A generalized east-west profile along the Marion County line, (shown in Figure 8), illustrates in cross-section the relationship between the glacial drift and the bedrock formations.

The bedrock topography of Hamilton County was characterized by steep valley walls and knob-like interfluves (see Figure 9). A rather deep, drift-filled valley extended through the county from the northwest to the southeast corner. A bedrock high of 800 feet above sea level was found in the southwestern part of the county near Clarksville, while a large elongate bedrock low of 600 feet above sea level was found in the northwest corner where preglacial flow in the bedrock valley apparently exitted Hamilton county.



DEVONIAN AND MISSISSIPIAN AGE
NEW ALBANY BLACK SHALE

DEVONIAN AGE
LIMESTONE AND DOLOMITE

SILURIAN AGE
NIAGARAN SERIES; LIMESTONE, DOLOMITE, AND CALCAREOUS SILTSTONE

LATE ORDOVICIAN SHALE AND LIMESTONE

FIGURE 7 BEDROCK GEOLOGY OF HAMILTON COUNTY

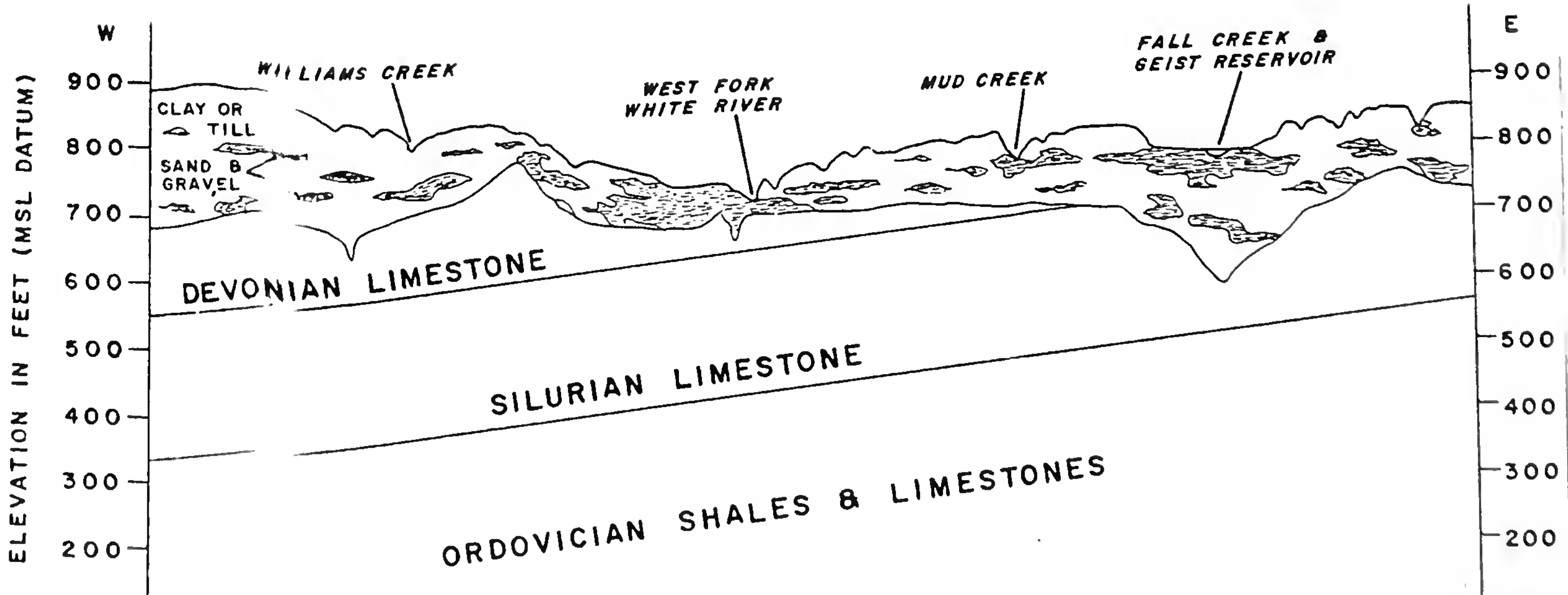
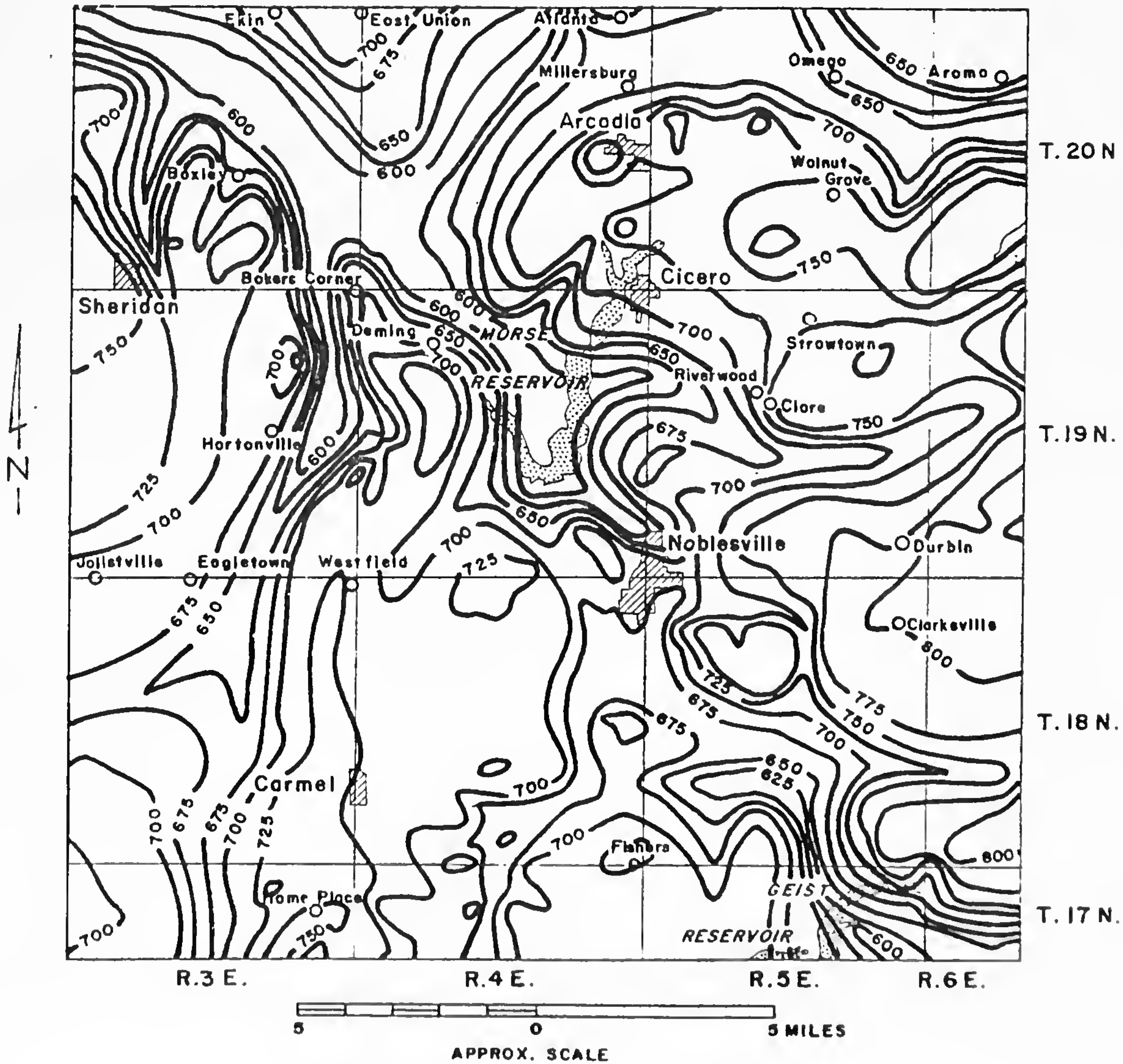


FIGURE 8. GENERALIZED EAST-WEST GEOLOGIC CROSS-SECTION ALONG HAMILTON-MARION COUNTY LINE (Greatly Exagerated Vertically) (7)



CONTOUR INTERVAL, 25 FEET

FIGURE 9. BEDROCK TOPOGRAPHY OF HAMILTON COUNTY

The bedrock of Hamilton County was a part of both the Scottsburg Lowland and Bluffton Plain bedrock physiographic provinces of Indiana. Bedrock in the western half of the county was geomorphically similar to areas of the Scottsburg Lowland exposed in southern Indiana, while bedrock in the eastern half more closely resembled areas of the Bluffton Plain. Figure 10 illustrates the location of Hamilton County with respect to these two bedrock physiographic provinces.

Borehole data from along SR 37 near Stoney Creek indicated bedrock was found at a depth of less than ten feet and was overlain by sand and gravel deposits (14). One of two operating limestone quarries found in Hamilton County was located along Stoney Creek about four miles east of Noblesville. The other limestone quarry, owned by the American Aggregate Company, was located just north of the Marion County line about one mile west of the West Fork White River. Both quarries produced crushed stone used for roadway subgrades and as aggregate for concrete.

Glacial Geology

The Kansan, Illinoian, and Wisconsinan glacial episodes all contributed to the overburden in Hamilton county (9). The effects of the Kansan and Illinoian glaciations lie buried beneath deposits of the more recent Wisconsinan glacial period. Some Illinoian (Butterville Formation) or Kansan (Cloverdale Formation) glacial drift may be exposed along the larger tributaries of the West Fork White River, where deep valleys have been eroded in the overlying Wisconsinan age drift. Drift thickness varied

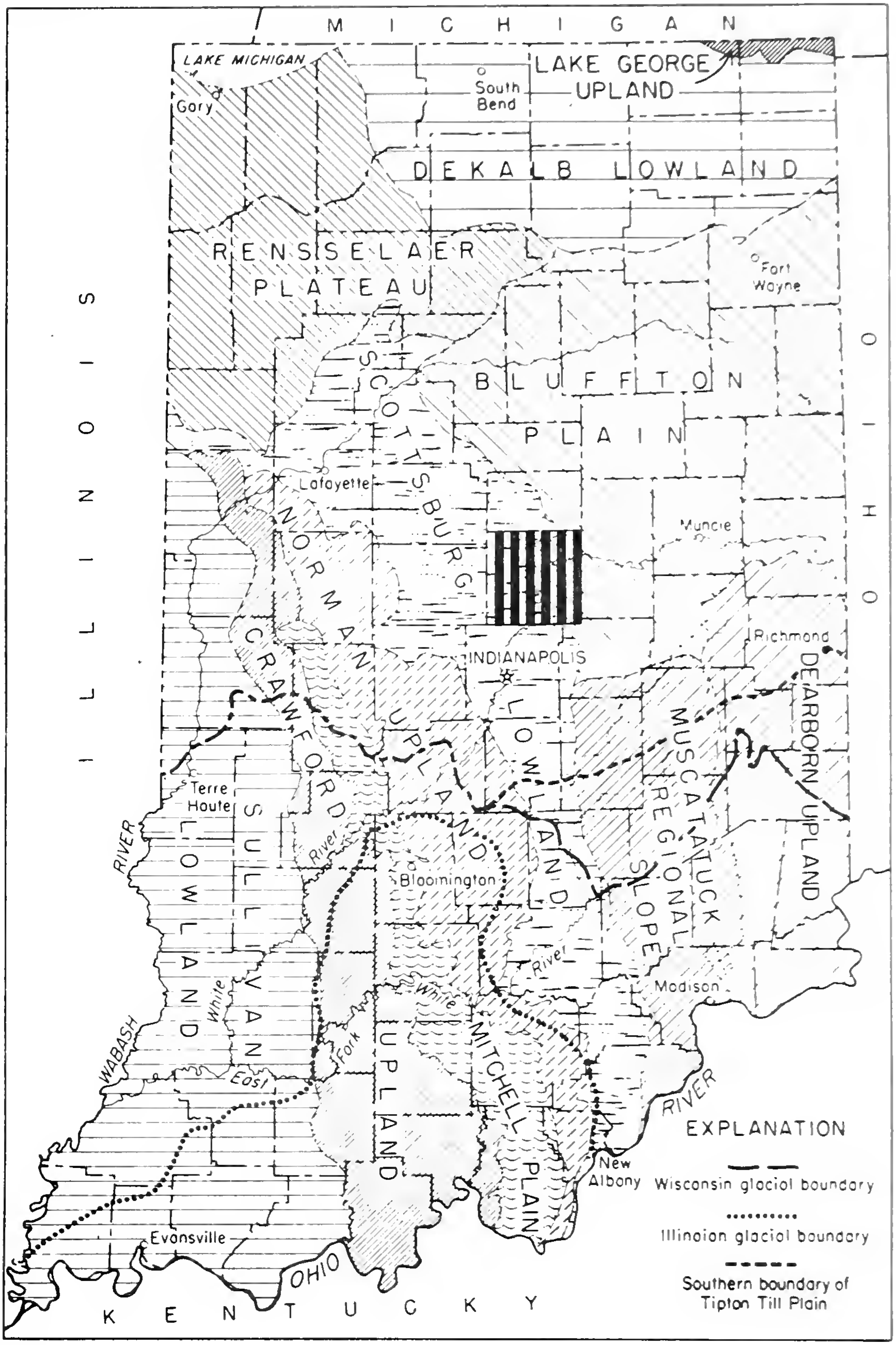


FIGURE 10. MAP OF INDIANA SHOWING BEDROCK PHYSIOGRAPHIC UNITS AND LOCATION OF HAMILTON COUNTY. MODIFIED FROM INDIANA GEOL. SURVEY REPT. PROG. 7, FIG. 3.

from as little as a few feet along Stoney Creek east of Noblesville (14) to over 400 feet near the northwest corner of the county, (see Figure 11).

All constructional glacial land forms in the county were a result of the Wisconsinan glaciation and were a part of the Trafalgar Formation (9). This glacial formation is composed primarily of a massive conglomeritic mudstone with minor amounts of gravel, sand, and silt. The Trafalgar Formation is divided into the upper Cartersburg Till Member and the lower Center Grove Till Member by a thin layer of fossiliferous silt known as the Vertigo alpestris oughtoni bed (9). Both Till members contain three facies of deposition; end moraine, ground moraine, and kame. Most of the constructional glacial features exposed at the surface in Hamilton County are a part of the Cartersburg Till Member of the Trafalgar Formation. Figure 12 shows the various facies typically found in the Tipton Till Plain physiographic province.

Many kames and several esker-like deposits were found in Hamilton County particularly in the north and northwest parts. A large kame with an abandoned gravel pit was located on S.R. 38 northwest of Sheridan just inside the Boone County line. A rather prominent esker-like feature was found that stretched across section 4, T20N, R 3E from the southwest corner to the northeast corner and continued into section 3,T20N, R 3E for several hundred yards.

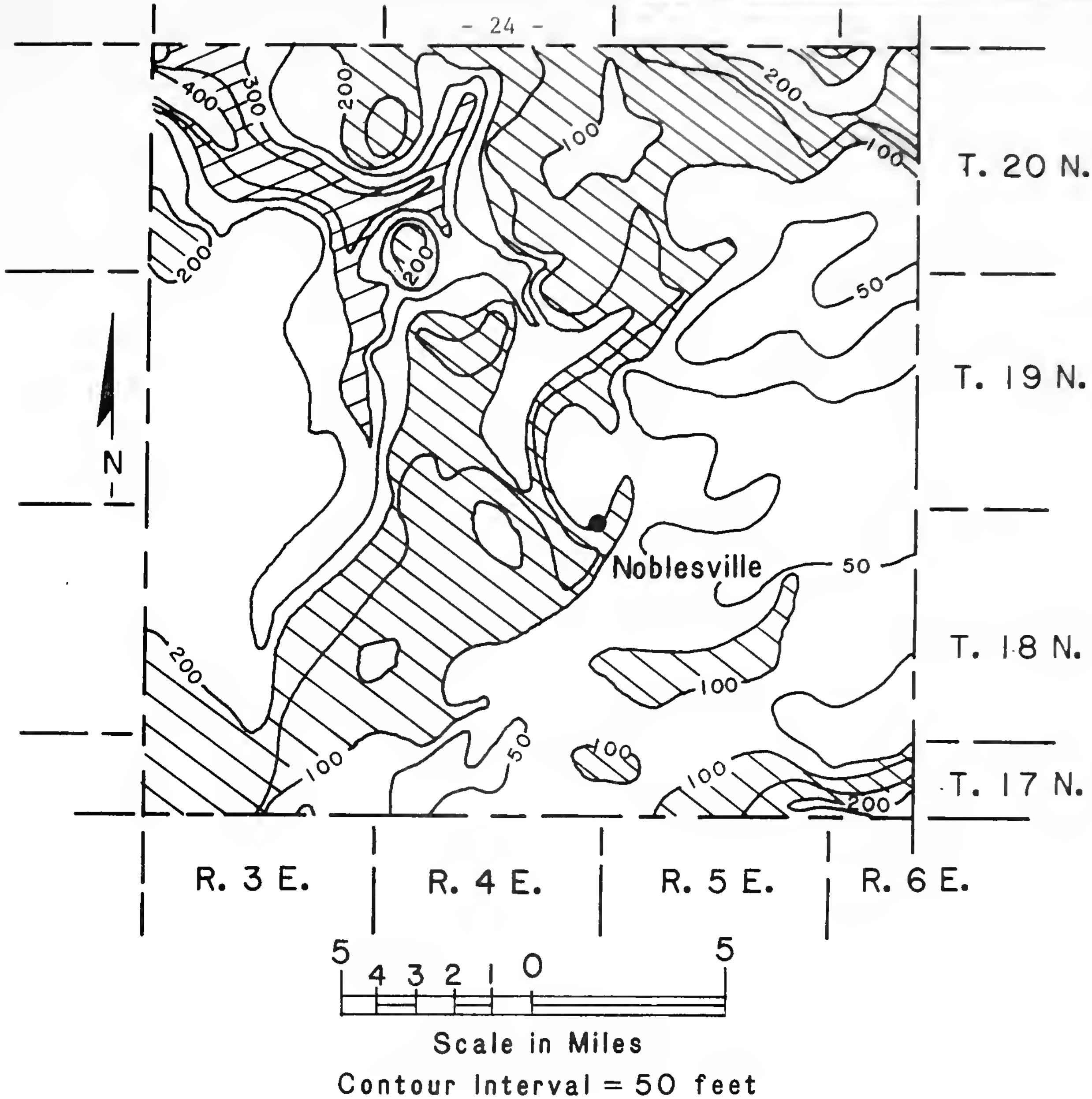


FIGURE 11. DRIFT THICKNESS IN HAMILTON COUNTY (19)

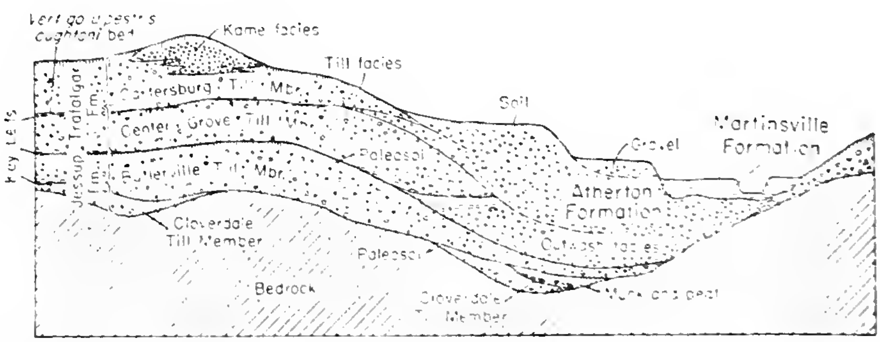


FIGURE 12. FACIES OF THE TIPTON TILL PLAIN GLACIAL DEPOSITS (9)

Ridge Moraine, a part of the Bloomington Morainic System as mapped by Malott (10) and Leverett (11), extended in an arc which varied from approximately two to seven miles in width that stretched from the northwest corner of the county to the west-central part of the county near the Marion County line. Most of the remaining part of the county that had not been influenced by glacio-fluvial activity was ground moraine. Small areas of highly organic topsoil and peat and muck were found in basins in both the ridge and ground moraine. Areas of peat and muck presumably had formed in association with ice block depressions or kettles. Areas of peat and muck were more common in the ridge moraine.

Outwash deposits in Hamilton County were rather extensive and were found in a wide band along the West Fork White River and along some of its major tributaries. Slender, interwoven glacial sluiceways traversed both ridge and ground moraine and were also found as remnant meltwater channels on the broad outwash terrace deposits. Large areas, (greater than 10 acres), of peat and muck were found both in the outwash terraces and along glacial sluiceways in the ridge and ground moriane. Several kames were also found associated with outwash deposits.

Engineering Soil Areas

Ice Contact Deposits

Ice contact deposits of Hamilton County, Indiana included ground moraine and ridge moraine. A band of ridge moraine

extended in an arc from the town of Sheridan southeastward into the central part of the county where it was truncated by the fluvial processes of the West Fork White River just north of the Marion County line. Ground moraine was the predominant land form-parent material association throughout the rest of the county and comprised most of the remaining surface area.

Ridge Moraine

The ridge moraine was characterized by hummocky topography with local relief ranging from about 10 to 30 feet. The greatest relief was found where the ridge moraine had been dissected by stream action, particularly in mid-southern Hamilton County west of the West Fork White River. The ridge moraine was well-defined in the northern part of the arc shown on the engineering soils map which accompanies this report. However, with decreasing distance to the West Fork White River, the rolling tracts of ridge moraine became less well-defined and were eventually lost in the area west of the river which had been largely dissected by its tributaries.

The swells and knolls in the ridge moraine were characterized by a sandy silt surface soil with some clay, which graded into a soil of roughly equal amounts of sand, silt, and clay, (a sandy clay loam), at a depth of between 15 to 36 inches in the B-horizon (2). Beneath this transitional zone, which extended to about 60 inches beneath the surface was found a sandy silt loam with small pebbles and some gravel. Boulders may also be present within the ridge moraine, perhaps occurring in boulder belts,

although no evidence of boulder belts was found in the literature or in the field.

Swales in the ridge moraine were characterized by a clayey silt surface soil with some sand which had washed off of the surrounding higher ground. The surface soil graded into a sandy silty clay layer at a depth of about 12 to 15 inches, which in turn graded into a clayey, sandy silt loam at a depth of 24 to 48 inches (2). The clayey sandy silt loam was underlain at a depth of about 48 to 60 inches by a sandy silt loam with some pebbles and occasional boulders, a characteristic parent material of ridge moraine. Typical generalized profiles developed from agricultural and roadway soil survey data as well as field sampling are shown for both high and low positions in the ridge moraine on the left-hand side of the engineering soils map.

Borehole data from a roadway soil survey along U.S. 31 (12) revealed the following texture-related variation with depth:

Table 4. Ridge Moraine Texture Data (boreholes 70, 71, 72) (12).

		Percent					
Depth (feet)	AASHTO	Sand	Silt	Clay	LL	PL	PI
0.0-2.0	A-6 (5)	50	30	20	32	16	16
2.0-3.5	A-7-6 (19)	15	45	40	53	22	31
3.5-5.0	A-6 (2)	55	15	30	26	15	11

The borehole profile data indicated the sandy texture of the near surface soils which was typical of the ridge moraine parent material. Note also the significant increase in plasticity in the B-horizon (2.0-3.5 feet). The strength data and other soil properties shown in Table 5 were obtained from tests conducted on samples taken from a borehole in ridge moraine about six hundred feet north of borehole #72 (see accompanying map).

Ground Moraine

Ground moraine in Hamilton County was characterized topographically by a gently undulating surface with local relief that generally did not exceed 10-15 feet. The broad, extensive, nearly flat areas of ground moraine were broken occasionally by stream dissection, ice block depression or kettles, and sandy knolls or kames. Old glacial sluiceways formed by the meltwaters of the Wisconsinan glaciation were found weaving their way across the ground moraine and were quite common, particularily in the eastern half of the county. Glacial sluiceways were also found in the ridge moraine, though they were not quite as common as in the ground moraine.

Swells in the ground moraine were characterized by a silt, or sandy silt loam surface soil which was underlain at a depth of about 12 to 15 inches by a clay loam. The clay loam graded into a sandy silt loam at a depth of about 24 to 48 inches (2). The sandy silt loam was underlain by a silty clay soil with some sand at a depth of about 60 to 84 inches which was the predominant parent material texture of the ground moraine.

Table 5. Properties and Strength Data For Ridge Moraine Soils (12).

Sample No.	Sample Depth, ft.	Lab. No.	Classification	AASHO No.	Natural Moisture (%)	Natural Dry Density (pcf)	Unconfined Compressive Strength (tsf)
1	2.0-4.0	14	Brown silty clay	A-7-6	16.7	113.8	1.12
2	6.0-8.0	10	Dark brown sandy loam with trace of organic matter	A-6	19.7	103.6	0.23
2	6.0-8.0	10	Dark brown sandy loam with trace of organic matter	A-6	21.7*	105.5*	0.08
3	8.0-10.0	10	Dark brown sandy loam with trace of organic matter	A-6	17.9	108.9	-

* From 7psi confining pressure

Swales in the ground moraine were characterized by a clayey silt surface soil which graded into a sandy silt loam at a depth of about 12 to 15 inches which in turn graded into a silty clay loam at a depth of about 24 to 36 inches (2). A sandy silt loam soil was generally found beneath the silty clay loam which eventually graded into a silty clay soil with some sand, (the characteristic parent material texture of ground moraine), at a depth of about 60 to 72 inches. Generalized profiles developed from agricultural and roadway soil survey data and field sampling are shown on the left-hand side of the Engineering Soils Map of Hamilton County for both high and low topographic positions in the ground moraine. Profiles for all subsequent engineering soils areas described are also shown on the map which accompanies this report.

Boreholes made for a soil survey along I-69 (13) in the southeast part of the county revealed the following localized textural data for ground moraine:

Table 6. Ground Moraine Texture Data (boreholes 32-42) (13).

		Percent					
Depth (feet)	AASHTO	Sand	Silt	Clay	LL	PL	PI
0.0-2.0	A-6 (8)	40	25	35	38	22	16
2.0-3.0	A-7-6 (16)	15	40	45	50	25	25
3.0-4.0	A-7-6 (12)	25	45	30	35	20	10
4.0-6.0	A-6 (10)	40	35	25	30	20	10
6.0-8.0	A-7-6 (18)	20	40	40	50	20	30

Much of the ground moraine near current watercourses and old glacial sluiceways was reworked by water. The action of the water resulted in a surface soil texture which was more coarse, (ie., higher sand content), than areas of ground moraine which were left essentially unaffected by this sheet-wash effect. Borehole data indicated that the influence of the fluvial action may have reached to a depth of 4.0-6.0 feet in some places as indicated by increased sand content. The content of sand in the upper 2.0 feet exceeded 60 percent in some places, with the sand content generally decreasing with depth. Local areas within the ridge moraine were subject to similar fluvial action and exhibited a correspondingly coarser surface soil texture. The areas which were reworked by water in both ground and ridge moraine were confined to locally low ground near current and abandoned watercourses. These areas were not delineated on the Engineering Soils Map of Hamilton County as specific engineering soils areas due to the ambiguity of the boundary between affected and unaffected land and the lack of sufficient borehole and field sampling data. However, areas which were most likely subject to the sheet-wash effect were delineated by textural boundaries (see map legend under miscellaneous) based on aerial photographic evidence. The engineering properties of surface soils developed in ground moraine obtained from a roadway soil survey along U.S. 31 in Hamilton County (12) are shown in Table 7 for boreholes 64 and 66 on the engineering soils map.

Table 7. Soil Properties of Ground Moraine Parent Material (12).

CBR TEST RESULTS

Lab. No: 4
Station: 372+10 b-16
Offset: 42'R
Depth: 2.0-3.0'
Description: Dark gray clay A-7-6(16)
Max. Std. Proctor Dry Density: 94.1 pcf
Optimum Moisture: 23.5%

Average Water Content, % As Molded	Average Water Content, % After Soaking	Initial Dry Density, pcf	% Max. Dry Dens. pcf	Swell, %	CBR, %
23.2	28.2	94.3	100.2	.08	4.6
23.1	27.7	93.8	99.7	.10	4.3
23.3	31.4	89.6	95.2	.12	1.8
24.0	31.8	88.4	93.9	.12	1.2
23.5	32.9	85.6	91.0	.12	0.5
23.6	32.5	84.2	89.5	.17	0.4
23.4	30.7				

Dry Density, pcf	% Max. Dry Density	Selected CBR, %
94.1	100	4.5
89.4	95	1.7
84.7	90	0.4

Table 7, continued

CBR TEST RESULTS

Lab. No: 1
Station: 308+00 B-4
Offset: 42'R
Depth: 3.0-3.5'
Description: Mottled gray and brown clay A-7-6(20)
Max. Std. Proctor Dry Density: 97.8 pcf
Optimum Moisture: 21.6%

Average Water Content, % As Molded	Average Water Content, % After Soaking	Initial Dry Density, pcf	% Max. Dry Dens. pcf	Swell, %	CBR, %
21.8	26.3	98.4	100.6	.08	6.3
21.6	26.7	96.8	99.0	.11	5.0
21.7	30.0	92.6	94.7	.18	2.7
21.7	30.6	92.4	94.5	.17	2.4
2.8	31.9	88.2	90.2	.29	1.1
21.7	33.5	87.8	89.8	.28	1.3
21.7	29.8				

Dry Density, pcf	%Max. Dry Density	Selected CBR, %
97.8	100	5.8
92.9	95	2.8
88.0	90	1.3

The pedalogical soil series that were most common on ridge and ground moraine in Hamilton County were the Miami, Crosby, and Brookston. Table 8 shows the relative distribution of these soils in Hamilton County.

Table 8. Relative Distribution of Soil Series Developed on Ground and Ridge Moraine.

Soil Series	Percent of County Area
Brookston	24.4
Crosby	36.5
Miami	17.8
	78.7 total

These soil series cover nearly 80% of the surface area of Hamilton County and were developed on ridge and ground moraine. There were minor inclusions of soil series other than the three primary ones which were found on ridge and ground moraine. The engineering properties of these and all other soil series subsequently listed with regard to the engineering soil areas are given in Appendix B of this report.

Glacio-Fluvial Deposits

Outwash Terraces

Broad terraces of outwash sands and gravels were found along the West Fork White River in Hamilton County. Smaller outwash

terraces were found along the main tributaries to the West Fork White River. Outwash terraces differed from recent river terraces in that the material of which they were composed was derived from the Wisconsinan glacial ice sheet and deposited by meltwater. More recent terraces which were formed by the action of runoff water collected upstream in the West Fork White River drainage basin were composed of recently eroded sediment or reworked outwash sands and gravels. The outwash terraces were generally more broad and extensive than the recent river terraces, which were mostly confined to the immediate vicinity of the West Fork White River and its tributaries.

Both outwash and recent river terraces were formed by similar processes and subsequently were composed of similar parent materials on which similar surface soils developed. Outwash terraces, in general, exhibited greater variation in texture laterally, (if for no other reason than they were broader and had probably been deposited by water that varied more greatly in velocity and sediment size carrying capacity), and usually were more poorly sorted and were generally more coarse than their contemporary counterparts.

Outwash terrace deposits were commonly overlain by approximately 12 inches of a silt loam or sandy silt loam surface soil. The surface soil was underlain to a depth of about 36 to 48 inches by a sandy loam or sandy silty clay loam soil. Beneath this zone was found a somewhat poorly stratified deposit of sand,

silt, and gravel with occasional boulders and minor amounts of clay, which comprised the basic unmodified parent material of the outwash terraces.

A roadway soil survey along SR. 37 (14) just north of Stoney Creek obtained borehole data from a transitional zone between recent river and outwash terraces. Data from borehole #62 indicate that a sandy clay or sandy clay loam soil was underlain at a depth of about seven feet by dense sand and gravel and a boulder was struck at a depth of approximately eight feet in another borehole nearby.

Pedalogical soil series that had developed in outwash terrace parent materials include the Nineveh, Ockley, Fox, Sleeth, and Westland. The Sleeth and Westland soils were found in the low areas on the outwash terraces and were commonly associated with abandoned glacial sluiceway channels. The Nineveh soil series was similar to the Ockley and Fox series which were located on the high topographic positions in the outwash terraces. The Sleeth and Westland Soils were not considered in determining the percentage of the Hamilton County surface area occupied by outwash terraces, as they have been included in the glacial sluiceway and recent river terrace areas.

The Fox and Ockley soil series were the predominant series which were developed on outwash terraces, however, they were also found on recent river terraces. Their combined areas along with that of the Nineveh soil series have herein been taken as a rough

estimate of the surface area of Hamilton County occupied by outwash terraces. This estimate was reasonable because the outwash terraces were much more extensive than the recent river terraces and the primary soil series developed on the recent river terraces was the Westland (2). Table 9 contains information concerning the areal distribution of soil series developed on outwash terraces in Hamilton County.

Table 9. Relative Distribution of Soil Series Developed on Outwash Terraces. (2)

Soil Series	Percent of County Area
Fox	1.5
Ockley	3.3
Nineveh	0.1
	4.9 total

Glacial Sluiceways

Glacial sluiceways were found within both outwash terraces and ground moraine. They were also found where the glacial meltwaters were able to make their way through areas of ridge moraine. In some cases, particularly in the western half of the county in the ridge moraine, old glacial sluiceways were occupied by streams which had reworked the sluiceway sediments and had deposited recent alluvial material over them. In many instances, the soils toward the upper reaches of the streams near

the watershed divides were still characteristic of those found on virtually undisturbed glacial sluiceway sediments. Other glacial sluiceways, mostly in the eastern third and northwest parts of the county were abandoned, particularly in areas of ground moraine, and served as drainageways only with the aid of man-made trenches.

Sluiceways over Outwash Terraces

Glacial sluiceways within outwash terraces were characterized by a silt, sandy silt, or sandy silt loam surface soil which extended to a depth of approximately 12 to 18 inches (2). The surface soil was underlain by a clayey silt, sandy silt loam or a soil that was a combination of sand, silt, and clay but not loamy. This layer extended to a depth of about two to five feet where it graded into a somewhat poorly stratified mixture of sand, silt, and gravel, which was the basic texture of the outwash terrace parent material. This layer was underlain by dense sands and gravels with lower silt contents. In some places, particularly in the vicinity of Stoney Creek and in the sluiceway system near the quarry located between S.R. 38 and S.R. 32 in the east-central part of the county, the outwash terrace sediments were underlain at relatively shallow depth by limestone (2). The presence of limestone in this area at relatively shallow depth, (6.0′-8.0′), was confirmed by borehole data from a roadway soil survey (14) along S.R. 37, as already noted. However, no borehole data was available to develop a site-specific

characterization of the textural variation with depth in a glacial sluiceway over outwash terraces.

Sluiceways on Ground Moraine and Ridge Moraine

Glacial sluiceways on ground moraine were located both east and west of the West Fork White River. The surface soil was typically a loam or silty clay loam and extended to a depth of approximately 12 to 15 inches. A loam or clay loam soil was found beneath the surface soil to a depth of about 30 inches. A sandy clay loam or silt loam was generally found between 30 and 50 inches, commonly containing thin, stratified lenses of fine sand and silt. The soil may contain up to 10 percent gravel in this layer (2). From 50 to about 60 inches was found a silt loam or sandy silt loam with lenses of fine and very fine sand with silt. Gravel content in this layer was commonly between 5 to 10 percent (2). Sluiceways in ridge moraine exhibitted similar texture variation with depth though in general they were more coarse and were underlain by ridge moraine parent material.

Glacial sluiceways were used as a source of sand and gravel in the past as recorded in the 1941 aerial photography of Hamilton County. Large and small bodies of water were found in glacial sluiceways on the photographs where sand pit operations had been abandoned. Sand pits were still operating in glacial sluiceways in Hamilton County at the time this report was written, though most of these were located in areas of underlying outwash which eventually provided gravel as a source for additional revenue.

Roadway Soil Survey data from along I-69 (13,15), shown in Table 10, revealed the following texture-related data for glacial sluiceways on ground moraine in Hamilton County:

Table 10. Glacial Sluiceways on Ground and Ridge Moraine Texture Data (boreholes 18 and 51), (13,15)

		Percent					
Depth (feet)	AASHTO	Sand	Silt	Clay	LL	PL	PI
0.0-2.0	A-4 (8)	20	60	20	30	20	10
2.0-4.0	A-2-4 (0)	75	15	10	NP	NP	NP
4.0-6.0	A-6 (6)	50	30	20	30	15	15
6.0-7.0	A-2-6 (1)	80	10	10	36	17	19

The texture data shown in Table 10 indicates that glacial sluiceway soils over ground moraine were typically high in sand content with low plasticity indexes. Data from adjacent boreholes not shown on the engineering soils map indicated that sluiceway sediments extend to a depth of 15 to 20 feet or more in some places. Table 11 shows the relative distribution of the pedalogical soil series which were developed on glacial sluiceways over ridge and ground moraine and outwash terraces.

Table 11. Distribution of Soil Series Developed on Glacial Sluiceways (2).

Soil Series	Percent of County Area
Patton	4.5 (in places over shallow limestone)
Whitaker	0.4
Milton Variant	0.3
Randolph Variant	0.1
Sleeth	0.4
	5.7 Total

Kames and Eskers

Kames and eskers are both coarse grained meltwater deposits and, although they are generally different in shape, they will herein be considered as a single engineering soil area.

Kames and eskers in Hamilton County generally had a sandy silt surface soil which extended to a depth of approximately 18 to 24 inches. From 24 to about 48 inches was found a clay loam or sandy clay loam. Beneath 48 inches, kame and esker deposits commonly graded into poorly stratified coarse sands and gravels, gradually decreasing in fines with depth. The kames and eskers were not extensively utilized as a source of sand and gravel in Hamilton County due to the large amounts of coarse-grained sediments found in the outwash terraces along the West Fork White River. No borehole data was available for kames and eskers and they comprised less than one percent of the county area (2).

Alluvial Deposits

Flood Plains

Flood plains were found along the West Fork White River and its tributaries in Hamilton County. The flood plain of the West Fork White River was rather extensive and exceeded a mile in width near Noblesville and Strawtown. Well developed flood plains were also found on Cicero and Fall Creeks, though these were largely covered by Morse and Geist Reservoirs respectively.

The surface soils on flood plains in Hamilton County were primarily loams and silt loams and were found to a depth ranging from approximately 39 to 60 inches according to agricultural soil survey data (2). A sandy loam or sandy clay loam soil was found beneath a depth of 39 to 60 inches. Sandy loam extended to a depth of nine feet or more or was underlain at a depth of approximately five feet by coarse sand and gravel. Interbedded lenses of sand and gravel were not uncommon in the sandy loam and sandy clay loam.

The following borehole data was obtained for flood plain deposits in Hamilton County from roadway soil surveys (13,15):

Table 12. Flood Plain Texture Data (13,15).

Depth (feet)	Textural Classification	AASHTO
	Borehole 30	
0-2	Silty clay loam	A-4
2-6	Med. dense sand	A-1-6 (0)
	Borehole 49	
0-2	Sandy loam	A-2-4
2-6	loam	A-6
6-8	Sandy loam	A-4

Numerous operating and abandoned sand and gravel pits were located within the alluvial flood plains found in Hamilton County. The pits found along the smaller tributaries to the West Fork White River were more likely to be producing sand, while those found within the flood plain of the West Fork White River were more likely producing both sand and gravel. The higher content of gravel found in pits in the West Fork White River flood plain was attributed to the greater grain-size carrying capacity of that river in the past and the redistribution of coarse sands and gravel from old meltwater outwash deposits found within the West Fork White River Valley that subsequently was reworked by the river. Several deposits of peat and muck were also found within the flood plains in Hamilton County, primarily adjacent to the valley walls. Table 13 shows the relative distribution of the soil series developed on flood plains as a percent of total county area.

Table 13. Distribution of Soil Series Developed on Flood Plains (2).

Soil Series	Percent of County Area
Genesee	1.3
Ross	0.3
Shoals	2.6
Sloan	0.5
	4.7 total

Recent River Terraces

Recent river terraces were similar in nature to outwash terraces and developed similar surface soils although not to as great a depth. Recent river terraces were found immediately adjacent to the West Fork White River and its main tributaries. They were formed by post-meltwater fluvial activity and were relatively thin deposits of recently eroded sand and gravel over till or thick deposits formed from reworked outwash material as well as recently eroded sediments. They were commonly more well sorted and finer grained than the older outwash terraces.

A silt loam or silty clay loam surface soil was commonly found on recent river terraces extending to a depth of approximately 15 inches. Sandy clay loam or sandy gravelly clay loam was found beneath the surface soil to a depth of about 36 to 48 inches. Stratified sands and gravels, the parent material of

recent river terraces, were found beneath approximately 48 inches. The underlying sand and gravel deposit also contained variable amounts of silt, some boulders, but little clay.

Borehole #61, shown on the Engineering Soils Map of Hamilton County, was drilled in a recent river terrace of thin, reworked outwash over limestone bedrock. The textural data is shown in Table 13 (14).

Table 13. Recent River Texture Data (borehole #61) (14)

Depth (feet)	Textural Classification	AASHTO
0-3.0	clay with trace gravel and cobbles	A-6
3.0-6.3	Sandy clay loam with trace gravel, cobbles and boulders	A-2-7 (3)

Based on surrounding borehole information, limestone bedrock was probably within three feet of the bottom of test hole #61. The boulders encountered in the borehole were indicative of surficial weathered regolith above the limestone.

The Westland and Sleeth pedalogical soil series were found to predominate on recent river terraces (2). Table 14 shows the relative distribution of these soil series in Hamilton County.

Table 14. Relative Distribution of Soil Series Found on Recent River Terraces (2).

Soil Series	Percent of County Area	
Westland	1.9	
Sleeth	0.4	
	2.3	Total

Depressional Deposits

Peat and Muck

Several large areas (40-80 acres) of peat and muck were found in Hamilton County. Smaller deposits of peat and muck were commonly associated with ice block depressions or kettles in the ridge and ground moraine. Two of the larger deposits were also apparently of this type and were located in section 33, T 20 N, R 4 E and section 24, T 19 N, R 4 E.

Deposits of peat and muck were either relatively shallow, extending to a depth of less than 51 inches (Palm soil series) or quite deep, extending to a depth greater than 51 inches (Houghton soil series). The thin deposits of peat and muck were underlain at shallow depth by the parent material of the surrounding land form, typically a silty clay loam or clay loam in the case of ridge and ground moraine.

Numerous deposits of peat and muck were found along glacial sluiceway channels and between the flood plain and terrace, and terrace and valley wall of the West Fork White River and its main tributaries in Hamilton County. Several smaller deposits were

also associated with sinkholes in thin drift-covered limestone. This possibility is especially prevalent east and northeast of Noblesville in the vicinity of Stoney Creek and Strawtown, where limestone bedrock is known to be within five to ten feet of the surface.

No borehole information was available for areas of peat and muck in Hamilton County. However, it was known from past experience that sapric soil material may extend to tens of feet in these deposits. Deposits of peat and muck comprised less than one percent of the total county area (2).

Highly Organic Topsoils

Deposits of highly organic topsoils were found throughout Hamilton County. These deposits were formed in shallow depressions or swales, primarily in ridge and ground moraine. The soils had a lower organic content than deposits of peat and muck, and that portion of the soil profile containing organic material was confined to the near-surface sediments.

The surface soil of deposits of highly organic topsoils was fine textured and commonly belonged to the Patton or Brookston series. Much of the surface sediment found in the depressions of highly organic topsoils was derived from the surrounding side slopes. Highly organic surface soils commonly extended to a depth of approximately 10 to 15 inches and were underlain by a silty clay loam to depths of 15 to 60 inches (2). A sandy silt loam or sandy silty clay loam was found beneath the silty clay

loam. Deposits of highly organic topsoils comprise less than two percent of the total county area (2).

Shallow Water Lacustrine Deposits

One shallow water lacustrine deposit was found in Hamilton County near the town of Sheridan (see accompanying map). It was originally located and tentatively identified as a lacustrine deposit on the aerial photographs by stereoscopic inspection and surface texture appearance. The deposit appeared to be relatively flat and was approximately one square mile in area. Field work found the area to be boardered to the east, north, and south by a rather abrupt topographic rise in the land surface, as much as 20-30 feet in some places. Ridge moraine cradles the area on all sides except to the west, where ground moraine was found. This lacustrine deposit was developed in an old, large ice block depression.

The agricultural soil survey identified the soils in the lacustrine area outlined on the photomosaic as belonging to the Patton and Brookston series. The surface soil was typically a silty clay loam and extended to a depth of 12-18 inches. A silty clay loam or clay loam was commonly found beneath the surface soil to a depth of approximately 38-46 inches. A clay loam, sandy clay loam, or loamy soil was found beneath about 46 inches. Field sampling revealed a yellow-gray, mottled, silty clay soil to be present in the B horizon (12-32 inches) in some places.

Summary

The major engineering soil areas of Hamilton County were divided into four basic groups and one miscellaneous group based on their associated agricultural pedalogical soil series, which had similar engineering properties and difficulties. Table 15 lists the engineering soil areas and their relative distribution as a percent of total county area.

Table 15. Distribution of Major Engineering Soils Areas in Hamilton County (2).

Engineering Soil Area	Percent of County Area
Ridge and Ground Moraine	78.7
Recent River and Outwash Terraces	7.2
Glacial Sluiceways	5.7
Flood Plains	4.7
Other (Kames, eskers, peat, muck, etc.)	3.7
	100.0 total

The percent-area information for the various engineering soils areas and groups is provided for the benefit of the reader and are estimates based on parent material association with pedalogical soil series. The probability of encountering any given engineering soils group and its associated engineering problems may be useful in the preliminary planning stages of an engineering project in Hamilton County.

Bibliography

1. Frost, R. E., et.al., "Manual on the Airphoto Interpretation of Soils and Raks for Engineering Purposes" Joint Highway Research Project, Purdue University, Lafayette, Indiana, 1943 (out of print).

2. Hosteter, W. D., et.al., "Soil Survey of Hamilton County, Indiana", U. S. Department of Agriculture, Soil Conservation Service in cooperation with Purdue University Agricultural Experiment Station, 1978.

3. "1980 Census of Population, General Population Characteristics - Indiana", U. S. Department of Commerce, Bureau of the Census, Population Division, U. S. Government Printing Office, Washington, D. C. 20402.

4. "Indiana Fact Book, 1979", Indiana State Planning Services Agency, Suite 300, Harrison Bldg. 143 W. Market Street, Indianapolis, IN 46204.

5. Logan, W. N., et.al., "Handbook of Indiana Geology", Indiana Department of Conservation, Division of Geology, Indianapolis, IN, 1922.

6. Yeh, P. T., "Drainage Map of Hamilton County," Joint Highway Research Project, Purdue University, 1954.

7. Herring, W. C., "Water Resources of Hamilton County", State of Indiana Department of National Resources, Division of Water, 1971.

8. a. Gray, H. H., et.al., "Geologic Map of the Cincinnati Quadrangle," Dept. of Natural Resources, Indiana Geological Survey in cooperation with the Illinois State Geological Survey, 1972.

b. Gray, H. H. and Wier, C. E., "Geologic Map of the Indianapolis Quadrangle", Dept. of Conservation, Indiana Geological Survey in cooperation with the Illinois State Geological Survey, 1961.

c. Burger, A. M., et.al., "Geologic Map of the Muncie Quadrangle," Dept. of Natural Resources, Indiana State Geological Survey, 1971.

d. Keller, S. J., et.al., "Geologic Map of the Danville Quadrangle," Dept. of Natural Resources, Indiana State Geological Survey in cooperation with the Illinois State Geological Survey, 1966.

9. Wayne, W. J., "Pleistocene Formations in Indiana," Geological Survey Bulletin No. 25, Indiana Department of Conservation, Bloomington, IN, 1963.

10. Malott, C. A., "Physiography of Indiana," Indiana Department of Conservation, Publication 21, 1922.

11. Leverett, Frank, "The Wisconsin Drift Border", U. S. Geological Survey, Monograph 53, 1915.

12. "Report of Roadway Soil Survey, Project F-222 (9) P.E. U. S. 31, Hamilton County, IN. (E-67164)," prepared for Floyd Burroughs and Associates, Indianapolis, IN. by American Testing and Engineering Company, Indianapolis, IN, August, 1968.

13. "Roadway Soil Survey, Project I-69-1 (27) 6, Hamilton County, Indiana", prepared for Shaffer, Parret, and Associates, Indianapolis, IN., by American Testing and Engineering Company, Indianapolis, IN, May, 1964.

14. "Roadway Soil Survey, F-Project No. 097-7 (2), S. R. 37, Hamilton County, Indiana," prepared by Monical Associates, Inc. Consulting Engineers, Indianapolis, IN., 1978.

15. "Roadway Soil Survey, Project I-69-1 (26) 0, Marion and Hamilton Counties, Indiana, prepared by American Testing and Engineering Corp. for Fleck, Quebe and Ried, Associates, Indianapolis, IN, February, 1964.

16. "Roadway Soil Survey, Project I-465-4 (102) 130, Hamilton County, Indiana", prepared for Pierce, Gruber & Beam, Inc., Indianapolis, Indiana, by American Testing and Engineering Corporation, Indianapolis, IN., January, 1964.

17. "Roadway Soil Survey, Project I-69-1 (28) 12 P. E. Hamilton County, Indiana," prepared for Boyd E. Phelps, Inc., Indianapolis, IN., by the H. C. NUTTING Company, Cincinnati, OH., October, 1964.

18. "Roadway Soil Survey, I-project No. 465-4 (106) (127), Hamilton County, Indiana," prepared for Alden E. Stilson and Associates, Ltd., Columbus, OH., by the H. C. NUTTING Company, Cincinnati, OH., May, 1964.

19. "Map of Indiana Showing Thickness of Unconsolidated Deposits", by Henry H. Gray, Indiana Department of Natural Resources, Geological Survey, 1983.

Appendix - A Borehole Data

Job Borehole Number	Map Borehole Number	Station	Offset	Sample depth feet	Classification: Textural	Classification: AASHO	Percent: Sand	Percent: Silt	Percent: Clay	LL	Pl	PI
					Job - I Project 465-4(107)130 (16)*							
69	1	588+00	42'Lt	2.5-4.0	Brown clay loam	A-6(9)	27	44	29	33	20	13
74	2	601+00	42'Rt	16.0-18.0	Gray Sandy loam	A-4(2)	58	26	16	15	10	5
73a	3	611+50	70'Lt	2.0-4.0	Brown Sand	A-1-b(0)	84	11	5	NP	NP	NP
81	4	620+42	30'Lt	4.0-6.0	Brown Sandy Clay loam	A-4(3)	54	26	20	24	16	8
84	5	629+00	42'Rt	2.0-4.0	Mottled Brown&Gray Clay	A-7-6(16)	8	49	43	48	22	26
88	6	639+00	42'Rt	1.0-2.5	Brown Silty Clay	A-7-6(18)	9	53	38	51	22	29
92	7	651+00	42'Rt	4.0-6.0	Reddish Br Sdy loam	A-2-4(0)	69	17	14	20	16	4
					Job-I Project 465-4(106)127 (18)							
4	8	712+00	42'Rt	1.0-2.0	Br. clay, trace gravel	A-7-6(15)	22	42	36	48	25	23
8	9	721+56	42'Rt	5.0-6.0	Br. Sndy lm.,trace gra.	A-4(2)	55	28	17	22	13	9
13	10	736+00	42'Lt	1.0-2.0	Brown & Gray Clay	A-7-6(14)	25	38	37	46	23	23
16	11	742+50	42'Rt	18.5-20.0	Gr. clay lm., gravel	A-4(3)	50	30	20	18	12	6
18	12	748+00	42'Rt	19.0-20.0	Brown Sand,Same gravel	A-1-b(0)	91	7	2	NP	NP	NP
21	13	755+00	42'Lt	18.5-20.0	Brown Sand with gravel	A-1-a(0)	87	10	3	NP	NP	NP
					Job-I Project No. 69-1(26)0 (15)							
20	14	167+00	37'Rt	4.0-6.0	Mottled Sandy clay loam	A-6(4)	50	30	20	27	15	12
28	15	192+15	37'Rt	4.0-6.0	Brown Silty Clay	A-6(10)	15	54	31	35	20	15
32	16	208+00	37'Rt	2.0-6.0	Brown Clay	A-6(11)	36	33	31	37	16	21
33	17	212+65	37'Rt	2.0-6.0	Mottled Silty Clay	A-7-6(17)	15	52	33	50	22	26

Job Borehole Number	Map Borehole Number	Station	Offset	Sample Depth in feet	Classification Textural	AASHO	Percent Sand	Silt	Clay	LL	PL	PI
43	18	251+00	37' Rt.	1.0-4.0	Brown Sandy Loam	A-2-4(0)	74	14	12	NP	NP	NP
44	19	255+00	37' Rt.	4.0-8.0	Brown Clay Loam	A-4(5)	42	33	25	24	14	10
45	20	259+00	37' Rt.	4.0-6.0	Brown Sandy Loam	A-6(6)	51	31	18	31	15	16
51	21	281+90	37' Rt.	6.0-8.0	Gray Sandy Loam	A-4(3)	51	31	18	19	12	7
58	22	309-79	42' Rt.	5.0-6.0	Brown Sandy Loam	A-4(5)	51	30	19	23	14	9
62	23	322+00	42' Rt.	5.0-6.0	Gray Clay Loam	A-4(6)	36	37	27	18	13	5
65	24	330-00	42' Lt.	1.0-3.0	Lt. Brown Sandy Clay	A-6(8)	52	16	32	40	19	21
69	25	342+00	42' Lt.	5.0-6.0	Mottled Clay	A-6(10)	36	33	31	39	19	20
73	26	353+75	42' Lt.	4.0-5.0	Mottled Silty Caly	A-7-6(18)	9	53	38	51	21	30
77	27	366+00	42' Lt.	5.0-6.0	Tan Sandy Loam	A-2-4(0)	72	18	10	22	16	6
79	28	372+00	42' Lt.	9.0-9.5	Brown Sandy Loam	A-2-4(0)	71	18	11	18	13	5
82	29	381+00	42' Rt.	3.0-4.0	Tan Clay Loam	A-6(6)	39	39	22	23	12	11
86	30	393+00	40' Rt.	5.0-6.0	Mottled Sand	A-1-b(0)	93	2	5	19	16	3
				Job - I Project 69-1(27)6 (13)								
1	31	399+00	42' Rt.	2.0-14.0	Brown Sandy Clay Loam	A-4(0)	65	14	21	22	13	9
4	32	408+00	42' Rt.	0.2-3.0	Light Brown Clay	A-6(8)	48	15	37	39	20	19
12	33	432+00	42' Rt.	2.0-3.0	Mottled Clay	A-7-6(19)	6	44	50	55	25	30
16	34	444+00	42' Rt.	5.0-6.0	Brown Clay Loam	A-6(5)	49	27	24	28	14	14
20	35	455+00	42' Rt.	3.0-4.0	Mottled Clay	A-7-6(14)	23	47	30	45	22	23
24	36	467+00	42' Rt.	0.0-2.0	Bl. Clay w/trace Organ.	A-7-6(15)	23	45	32	46	22	24
29	37	482+00	42' Lt.	4.0-6.0	Lt. Brown Clay Loam	A-4(6)	37	37	26	20	13	7

Job Borehole Number	Map Borehole Number	Station	Offset	Sample Depth in feet	Classification: Textural	Classification: AASHO	Percent: Sand	Percent: Silt	Percent: Clay	LL	PL	PI
34	38	494+00	42' Rt.	4.0-6.0	Tan Clay	A-6(9)	31	29	40	37	22	15
43	39	520+00	42' Lt.	9.0-10.0	Clay Loam w/trace Orgn	A-4(8)	31	47	22	19	14	5
45B	40	527+25	60' Rt.	10.-12.0	Gray Loam	A-4(4)	47	40	13	17	13	4
50	41	540+15	42' Lt.	7.0-8.0	Brown Sandy Loam	A-4(1)	63	27	10	NP	NP	NP
54	42	549+00	42' Rt.	3.0-4.0	Sdy. Cl. Lm w/Tr. Org.	A-7-5(6)	64	8	28	84	34	50
58	43	560+00	42' Rt.	4.0-6.0	Lt. Br. Clay Loam	A-4(5)	42	33	25	23	16	7
60	44	565+00	42' Rt.	0.5-2.5	Lt. Br. Silty Clay Lm.	A-6(9)	8	65	27	32	19	13
63	45	574+00	42' Lt.	5.0-6.0	Brown Sandy Loam	A-6(3)	53	29	18	27	16	11
67	46	581+60	42' Lt.	6.0-8.0	Mottled Clay	A-7-6(18)	20	41	39	50	20	30
82	47	604+00	42' Rt.	1.0-2.0	Lt. Gray Silty Cly Lm.	A-7-6(20	13	62	25	75	27	48
89	48	615+00	42' Lt.	3.0-10.0	Brown Silty Clay	A-7-6(18)	9	55	36	51	22	29
94	49	625+00	42' Rt.	1.0-2.0	Brown Clay	A-7-6(12)	34	34	32	41	18	23
100	50	634+00	42' Rt.	1.0-12.5	Gray Clay	A-6(9)	39	18	43	29	13	16
107	51	645+00	42' Lt.	6.0-7.0	Gray Sand	A-2-6(1)	82	7	11	36	17	19
					Job - I Project 69-1(28)12 (17)							
3	52	682+00	42' Lt.	5.0-6.0	Brown Loam w/gravel	A-4(3)	49	33	18	20	14	6
15	53	700+00	42' Lt.	1.0-2.0	Br.Gr.Clay, Trace Grvl.	A-7-6(16)	16	39	45	48	22	26
22	54	716+00	42' Rt.	1.0-2.0	Br. - Gr. Clay	A-7-6(16)	10	48	42	48	22	26
					Job - F Project No. 097-7(2) (14)							
S-3	55	620+24	2' Lt.	0.0-2.0	Clay	A-7-6(17)	27	32	41	43	19	24
S-311	56	624+00	37' Rt.	0.5-1.5	Clay	A-6(13)	21	48	31	40	23	17

Job Borehole Number	Map Borehole Number	Station	Sample Depth Offset (feet)	Classification Textural	AASHO	Percent Sand	Silt	Clay	LL	PL	PI
S-701	57	647+60	70' Lt. 0.7-2.0	Loam	A-4(1)	45	35	20	21	15	6
S-14	58	727+09	134'Lt. 0.0-2.0	Clay	A-6(13)	26	33	41	38	18	20
B-26	59	817+35	56' Rt. 3.5-5.0	Clay	A-6(6)	37	30	33	30	17	13
B-849-PT	60	849+82	38' Rt. 3.3-4.0	Clay Loam	A-6(8)	30	42	28	34	19	15
B-32	61	857+00	37' Rt. 3.5-4.0	Sandy Clay Loam	A-2-7(3)	65	13	22	46	21	25
B-36	62	881+21	37' Rt. 3.5-5.0	Sand	A-2-4(0)	84	7	9	NP	NP	NP
B-41	63	917-50	37' Rt. 3.5-5.0	Silty Clay Loam	A-6(10)	16	60	24	34	22	12
				Job - F Project #222 (9) P.E. (12)							
4	64	308+00	42' Rt. 3.0-3.5	Mottled Clay	A-7-6(20)	25	33	42	58	23	35
5	65	312+44	42' Rt. 5.0-6.0	Brown Clay Loam	A-4(6)	33	45	22	23	13	10
16	66	372+10	42' Rt. 2.0-3.0	Dark Gray Clay	A-7-6(16)	24	37	39	50	25	25
21	67	401+00	42' Rt. 0.5-2.0	Brown Clay	A-7-6(13)	24	42	34	41	18	23
26	68	433+00	42' Rt. 0.5-2.0	Brown, Sandy Clay	A-7-6(8)	55	15	30	48	21	27
29	69	450+00	42' Rt. 0.0-2.0	Brown Clay Loam	A-6(6)	39	35	26	28	16	12
34	70	490+00	42' Lt. 0.0-2.0	Sandy Lm. w/trace Org.	A-6(5)	52	29	19	32	16	16
37	71	512+00	42' Lt. 1.5-3.5	Brown Silty Clay	A-7-6(19)	4	53	43	53	22	31
39	72	532+30	42' Lt. 3.0-5.0	Br. Sandy Clay Loam	A-6(2)	58	14	28	26	15	11

*Note: Last number in parenthesis footnotes the references.

Job Borehole Number	Map Borehole Number	Station	Sample Depth Offset (feet)	Classification: Textural	Classification: AASHO	Percent: Sand	Percent: Silt	Percent: Clay	LL	PL	PI
S-701	57	647+60	70' Lt. 0.7-2.0	Loam	A-4(1)	45	35	20	21	15	6
S-14	58	727+09	134'Lt. 0.0-2.0	Clay	A-6(13)	26	33	41	38	18	20
B-26	59	817+35	56' Rt. 3.5-5.0	Clay	A-6(6)	37	30	33	30	17	13
B-849-PT	60	849+82	38' Rt. 3.3-4.0	Clay Loam	A-6(8)	30	42	28	34	19	15
B-32	61	857+00	37' Rt. 3.5-4.0	Sandy Clay Loam	A-2-7(3)	65	13	22	46	21	25
B-36	62	881+21	37' Rt. 3.5-5.0	Sand	A-2-4(0)	84	7	9	NP	NP	NP
B-41	63	917-50	37' Rt. 3.5-5.0	Silty Clay Loam	A-6(10)	16	60	24	34	22	12
				Job - F Project #222 (9) P.E. (12)							
4	64	308+00	42' Rt. 3.0-3.5	Mottled Clay	A-7-6(20)	25	33	42	58	23	35
5	65	312+44	42' Rt. 5.0-6.0	Brown Clay Loam	A-4(6)	33	45	22	23	13	10
16	66	372+10	42' Rt. 2.0-3.0	Dark Gray Clay	A-7-6(16)	24	37	39	50	25	25
21	67	401+00	42' Rt. 0.5-2.0	Brown Clay	A-7-6(13)	24	42	34	41	18	23
26	68	433+00	42' Rt. 0.5-2.0	Brown, Sandy Clay	A-7-6(8)	55	15	30	48	21	27
29	69	450+00	42' Rt. 0.0-2.0	Brown Clay Loam	A-6(6)	39	35	26	28	16	12
34	70	490+00	42' Lt. 0.0-2.0	Sandy Lm. w/trace Org.	A-6(5)	52	29	19	32	16	16
37	71	512+00	42' Lt. 1.5-3.5	Brown Silty Clay	A-7-6(19)	4	53	43	53	22	31
39	72	532+30	42' Lt. 3.0-5.0	Br. Sandy Clay Loam	A-6(2)	58	14	28	26	15	11

*Note: Last number in parenthesis footnotes the references.

Soil name and map symbol	Depth	USDA tex	High water table			Bedrock		Potentia frost action
			Depth*	Kind	Months	Depth	Hardness	
	In		Ft			In		
Br----------------- Brookston	0-11	Silty clay	0-1.0	Apparent	Dec-May	>60	---	High.
	11-49	Clay loam, clay loam						
	49-60	Loam, sand loam, cla loam.						
CrA----------------- Crosby	0-11	Silt loam-	1.0-3.0	Apparent	Jan-Apr	>60	---	High.
	11-32	Clay loam, clay loam						
	32-60	Loam, clay sandy loa						
FnA, FnB2---------- Fox	0-10	Loam------	>6.0	---	---	>60	---	Moderate
	10-16	Silty clay clay loam						
	16-36	Gravelly c loam to gravelly clay loam						
	36-60	Sand and g						
FxC3--------------- Fox	0-7	Clay loam-						
	7-28	Gravelly loam to clay loa						
	28-60	Sand and						
Ge----------------- Genesee	0-7	Silt loam-	>6.0	---	---	>60	---	Moderate
	7-38	Silt loam						
	38-60	Stratifie loam to						
Ho----------------- Houghton	0-60	Sapric ma	0-1.0	Apparent	Sep-Jun	>60	---	High.
MmA, MmB2, MmC2, MmD2--------------- Miami	0-7	Silt loam	>6.0	---	---	>60	---	Moderate
	7-30	Clay loam clay loa sandy cl loam.						
	30-60	Loam, cla sandy lo						
MxA---------------- Milton Variant	0-11	Silt loam	>6.0	---	---	40-50	Hard	Moderate
	11-26	Silty cla clay loa loam.						
	26-41	Clay, fla clay loa flaggy c						
	41	Weathered bedrock.						
NnA---------------- Nineveh	0-12	Loam-----	>6.0	---	---	>60	---	Moderate
	12-20	Clay loam clay loa						
	20-32	Gravelly loam.						
	32-60	Stratifie to very gravelly						

Appendix B — Table of Engineering Soil Properties.

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
Br------------------ Brookston	0-11	Silty clay loam	CL	A-6, A-7	0	100	98-100	95-100	75-95	36-50	15-25
	11-49	Clay loam, silty clay loam.	CL, CH	A-6, A-7	0	98-100	85-100	75-95	60-85	36-52	16-30
	49-60	Loam, sandy loam, clay loam.	CL	A-4, A-6	0-3	90-100	85-95	78-90	55-70	22-30	7-15
CrA----------------- Crosby	0-11	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	95-100	80-100	50-90	22-34	6-15
	11-32	Clay loam, silty clay loam.	CL, CH	A-6, A-7	0-3	92-99	89-97	78-93	64-76	37-55	17-31
	32-60	Loam, clay loam, sandy loam.	CL, ML, CL-ML	A-4, A-6	0-3	88-94	83-89	74-87	50-64	17-30	2-14
FnA, FnB2----------- Fox	0-10	Loam-------------	ML	A-4	0	95-100	85-100	75-95	55-90	20-30	2-4
	10-16	Silty clay loam, clay loam.	CL	A-6, A-7	0	85-100	75-100	70-95	55-90	25-45	10-25
	16-36	Gravelly clay loam to gravelly sandy clay loam.	CL, SC	A-6, A-2-6, A-7	0	85-100	75-95	50-95	20-65	25-45	10-25
	36-60	Sand and gravel	SP, SM, GP, GM	A-1, A-2, A-3	0-5	40-100	35-100	15-95	2-15	---	NP
FxC3---------------- Fox	0-7	Clay loam--------	CL	A-6	0	90-100	75-100	75-95	60-80	20-40	10-20
	7-28	Gravelly clay loam to sandy clay loam.	CL, SC	A-6, A-2-6, A-7	0	85-100	75-95	50-95	20-65	25-45	10-25
	28-60	Sand and gravel	SP, SM, GP, GM	A-1, A-2, A-3	0-5	40-100	35-100	15-95	2-15	---	NP
Ge------------------ Genesee	0-7	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	75-85	26-40	3-15
	7-38	Silt loam, loam	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	75-85	26-40	3-15
	38-60	Stratified sandy loam to silt	ML, CL, CL-ML	A-4, A-6	0	90-100	85-100	60-80	50-70	26-40	3-15
Ho------------------ Houghton	0-60	Sapric material	Pt	---	0	---	---	---	---	---	---
MmA, MmB2, MmC2, MmD2--------------- Miami	0-7	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	95-100	80-100	50-90	22-34	6-15
	7-30	Clay loam, silty clay loam, sandy clay loam.	CL	A-6, A-7	0	92-99	89-97	76-95	64-95	35-50	17-31
	30-60	Loam, clay loam, sandy loam.	CL, CL-ML, ML	A-4, A-6	0-3	88-94	83-89	74-87	50-64	17-30	2-14
MxA----------------- Milton Variant	0-11	Silt loam--------	ML, CL-ML	A-4	0-5	95-100	90-100	85-95	80-90	26-36	4-10
	11-26	Silty clay loam, clay loam, silt loam.	CL	A-6, A-7	0-10	85-95	80-95	75-95	65-90	30-45	15-25
	26-41	Clay, flaggy clay loam, flaggy clay.	CL, CH	A-7	5-20	75-95	70-95	65-95	55-90	45-60	26-40
	41	Weathered bedrock.	---	---	---	---	---	---	---	---	---
NnA----------------- Nineveh	0-12	Loam-------------	CL	A-6	0	95-100	95-100	75-95	50-75	25-35	10-15
	12-20	Clay loam, silty clay loam.	CL	A-6, A-7	0	95-100	90-100	85-100	65-80	35-45	15-25
	20-32	Gravelly clay loam.	SC, CL, GC	A-6, A-7	0-5	65-75	60-75	50-60	40-60	30-45	15-25
	32-60	Stratified sand to very gravelly sand.	SP, GP, SP-SM, GP-GM	A-1	0-5	30-70	20-55	5-20	0-10	---	NP

Soil name and map symbol	Depth	Permeability	Shrink-swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	High water table: Depth*	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hardness	Potential frost action
	In	In/hr				Ft			In		
Brookston	0-11	0.6-2.0	Moderate	High------	Low------	0-1.0	Apparent	Dec-May	>60	---	High.
	11-49	0.6-2.0	Moderate	High------	Low------						
	49-60	0.6-2.0	Moderate	High------	Low------						
Crosby	0-11	0.6-2.0	Low--------	High------	Moderate	1.0-3.0	Apparent	Jan-Apr	>60	---	High.
	11-32	0.06-0.2	Moderate	High------	Moderate						
	32-60	0.06-0.6	Low--------	High------	Low------						
Fox (FnA, FnB2)	0-10	0.6-2.0	Low--------	Low-------	Moderate	>6.0	---	---	>60	---	Moderate
	10-16	0.6-2.0	Moderate	Low-------	Moderate						
	16-36	0.6-2.0	Moderate	Low-------	Moderate						
	36-60	>6.0	Low--------	Low-------	Low------						
Fox (FxC3)	0-7	0.6-2.0	Moderate	Low-------	Moderate						
	7-28	0.6-2.0	Moderate	Low-------	Moderate						
	28-60	>6.0	Low--------	Low-------	Low------						
Genesee	0-7	0.6-2.0	Low--------	Low-------	Low------	>6.0	---	---	>60	---	Moderate
	7-38	0.6-2.0	Low--------	Low-------	Low------						
	38-60	0.6-2.0	Low--------	Low-------	Low------						
Houghton	0-60	2.0-6.0	----------	High------	Low------	0-1.0	Apparent	Sep-Jun	>60	---	High.
Miami	0-7	0.6-2.0	Low--------	Low-------	Moderate	>6.0	---	---	>60	---	Moderate
	7-30	0.6-2.0	Moderate	Moderate	Moderate						
	30-60	0.2-2.0	Low--------	Low-------	Low------						
Milton Variant	0-11	0.6-2.0	Low--------	Moderate	Moderate	>6.0	---	---	40-50	Hard	Moderate
	11-26	0.6-2.0	Moderate	Moderate	Moderate						
	26-41	0.6-2.0	Moderate	High------	Low------						
	41	---	----------	----------	----------						
Nineveh	0-12	0.6-2.0	Low--------	Low-------	Low------	>6.0	---	---	>60	---	Moderate
	12-20	0.6-2.0	Moderate	Low-------	Low------						
	20-32	0.6-2.0	Moderate	Low-------	Low------						
	32-60	>20	Low--------	Low-------	Low------						

Soil name and map symbol	Depth	USDA te	High water table: Depth	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hardness	Potential frost action
	In		Ft			In		
CoA, CoB2---------- Ockley	0-17	Silt loam	>6.0	---	---	>60	---	Moderate
	17-28	Silty cla clay loa						
	28-56	Clay loam gravelly clay loa loam.						
	56-70	Stratifie to grave sand.						
Orthents								
Pa---------------- Palms	0-29	Sapric m	0-1.0	Apparent	Nov-May	>60	---	High.
	29-60	Clay loa silty cl loam.						
Pn---------------- Patton	0-12	Silty cl	0-1.0	Apparent	Mar-Jun	>60	---	High.
	12-39	Silty cl						
	39-60	Stratifi loam to clay lo						
Ps---------------- Patton	0-13	Silty cl	0-1.0	Apparent	Jan-May	40-60	---	High.
	13-37	Silty cl						
	37-52	Stratifi clay lo sandy l						
	52	Unweathe bedrock						
Ra---------------- Randolph Variant	0-12	Silt loa	1.0-3.0	Perched	Jan-Apr	40-50	Hard	High.
	12-38	Clay loa clay lo gravell loam.						
	38-41	Silty cl silty c loam, g silty c loam.						
	41-44	Weathere bedrock						
	44	Unweathe bedrock						
Ro---------------- Ross	0-34	Loam, si	4.0-6.0	Apparent	Feb-Apr	>60	---	Moderate
	34-60	Loam, sa loam.						
Sh---------------- Shoals	0-11	Silt loa	1.0-3.0	Apparent	Jan-Apr	>60	---	High.
	11-39	Silt loa silty c loam.						
	39-56	Sandy lo sandy c loam.						
	56-60	Coarse s gravell						
Sb---------------- Sleeth	0-15	Loam	1.0-3.0	Apparent	Jan-Apr	>60	---	High.
	15-20	Clay loa clay lo						
	20-47	Sandy cl gravell clay.						
	47-60	Stratifi to grav sand.						

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
CoA, CoB2----------- Cokley	0-17	Silt loam, loam	CL, ML, CL-ML	A-4, A-6	0	100	95-100	80-100	60-90	22-33	3-12
	17-28	Silty clay loam, clay loam.	CL	A-6, A-4	0	100	75-100	65-90	50-90	20-35	8-17
	28-56	Clay loam, gravelly sandy clay loam, loam.	CL, SC, GC	A-6, A-7	0-2	70-85	60-90	50-75	35-60	30-45	11-25
	56-70	Stratified sand to gravelly sand.	SP, SP-SM, GP, GP-GM	A-1	1-5	30-70	20-55	5-20	2-10	---	NP
Orthents											
Pa---------------- Palms	0-29	Sapric material	Pt	---	---	---	---	---	---	---	---
	29-60	Clay loam, loam, silty clay loam.	CL-ML, CL	A-4, A-6	0	85-100	80-100	70-95	50-80	25-40	5-20
Pn---------------- Patton	0-12	Silty clay loam	CL	A-6	0	100	100	95-100	75-95	30-40	10-20
	12-35	Silty clay loam	CL, CH, ML, MH	A-7	0	100	100	95-100	80-100	40-55	15-25
	35-60	Stratified silt loam to silty clay loam.	CL	A-6	0	100	100	95-100	75-95	25-40	10-20
Ps---------------- Patton	0-13	Silty clay loam	CL, CH	A-6, A-7	0	100	100	90-100	50-95	35-55	20-35
	13-37	Silty clay loam	CL, CH	A-6, A-7	0	100	100	90-100	80-95	35-55	20-35
	37-52	Stratified silty clay loam to sandy loam.	CL	A-6, A-7	0	100	95-100	90-100	65-95	25-45	10-25
	52	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Ra---------------- Randolph Variant	0-12	Silt loam--------	ML, CL-ML	A-4, A-6	0-5	90-95	85-95	75-95	50-85	20-35	5-15
	12-38	Clay loam, silty clay loam, gravelly clay loam.	CL, CH	A-6, A-7	0-10	75-95	70-90	65-90	55-85	35-55	15-30
	38-41	Silty clay, silty clay loam, gravelly silty clay loam.	CL, CH	A-6, A-7	0-10	75-95	70-90	65-90	50-85	35-60	15-40
	41-44	Weathered bedrock.	---	---	---	---	---	---	---	---	---
	44	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Ro---------------- Ross	0-34	Loam, silt loam	ML	A-4	0	90-100	85-100	80-100	65-90	20-40	NP-10
	34-60	Loam, sandy clay loam.	ML	A-4, A-6	0	80-100	75-100	70-100	65-90	20-40	NP-12
Sh---------------- Shoals	0-11	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	90-100	65-90	22-35	6-15
	11-39	Silt loam, loam, silty clay loam.	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	75-85	25-40	4-15
	39-56	Sandy loam, sandy clay loam.	ML	A-4, A-2	0-3	90-100	85-100	60-80	35-60	32-40	3-5
	56-60	Coarse sand and gravelly sand.	SP, SP-SM	A-1, A-3	1-5	55-90	50-90	20-60	3-10	---	NP
Sl---------------- Sleeth	0-15	Loam------------	CL, ML, CL-ML	A-4, A-6	0	100	90-100	75-95	50-85	26-30	3-12
	15-20	Clay loam, silty clay loam.	CL	A-6	0	85-95	85-95	80-90	65-75	30-40	15-25
	20-47	Sandy clay loam, gravelly sandy clay.	CL	A-6	0-3	80-95	80-90	60-80	35-50	30-40	15-25
	47-60	Stratified sand to gravelly sand.	SP, SP-SM	A-1, A-3	1-5	50-80	45-75	25-55	2-10	---	NP

Soil name and map symbol	Depth	Permeability	Shrink-swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	High water table: Depth	Kind	Months	Bedrock: Depth	Hardness	Potential frost action
	In	In/hr				Ft			In		
CoA, CoB2 Cokley	0-17	0.6-2.0	Low--------	Low--------	Moderate	>6.0	---	---	>60	---	Moderate
	17-28	0.6-2.0	Moderate	Moderate	Moderate						
	28-56	0.6-2.0	Moderate	Moderate	Moderate						
	56-70	>20	Low--------	Low--------	Low--------						
Orthents											
Pa Palms	0-29	2.0-6.0	-----------	High-------	Moderate	0-1.0	Apparent	Nov-May	>60	---	High.
	29-60	0.2-2.0	Low--------	High-------	Low--------						
Pn Patton	0-12	0.6-2.0	Moderate	High-------	Low--------	0-1.0	Apparent	Mar-Jun	>60	---	High.
	12-35	0.6-2.0	Moderate	High-------	Low--------						
	35-60	0.6-2.0	Moderate	High-------	Low--------						
Ps Patton	0-13	0.6-2.0	Moderate	High-------	Low--------	0-1.0	Apparent	Jan-May	40-60	---	High.
	13-37	0.6-2.0	Moderate	High-------	Low--------						
	37-52	0.6-2.0	Moderate	High-------	Low--------						
	52	---	-----------	-----------	-----------						
Ra Randolph Variant	0-12	0.6-2.0	Moderate	High-------	Moderate	1.0-3.0	Perched	Jan-Apr	40-50	Hard	High.
	12-38	0.2-0.6	Moderate	High-------	Moderate						
	38-41	0.2-0.6	Moderate	High-------	Low--------						
	41-44	---	-----------	-----------	-----------						
	44	---	-----------	-----------	-----------						
Ro Ross	0-34	0.6-2.0	Low--------	Low--------	Low--------	4.0-6.0	Apparent	Feb-Apr	>60	---	Moderate
	34-60	0.6-2.0	Low--------	Low--------	Low--------						
Sh Shoals	0-11	0.6-2.0	Low--------	High-------	Low--------	1.0-3.0	Apparent	Jan-Apr	>60	---	High.
	11-39	0.6-2.0	Low--------	High-------	Low--------						
	39-56	0.6-2.0	Low--------	High-------	Low--------						
	56-60	2.0-6.0	Low--------	High-------	Low--------						
Sl Sleeth	0-15	0.6-2.0	Low--------	High-------	Low--------	1.0-3.0	Apparent	Jan-Apr	>60	---	High.
	15-20	0.6-2.0	Moderate	High-------	Low--------						
	20-47	0.6-2.0	Moderate	High-------	Low--------						
	47-60	>20	Low--------	Low--------	Low--------						

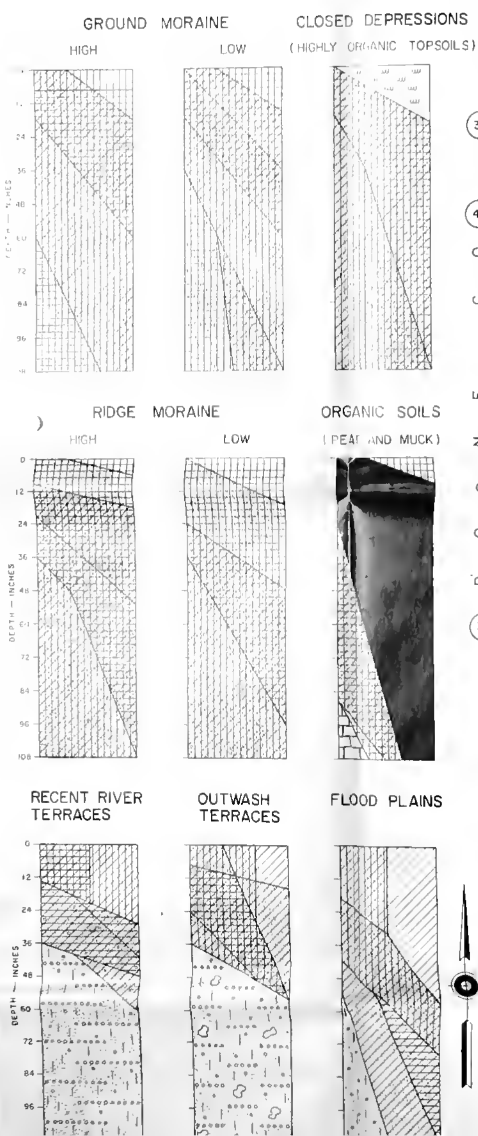
Soil name and map symbol	Depth	USDA tex	High water table Depth*	High water table Kind	High water table Months	Bedrock Depth	Bedrock Hardness	Potential frost action
	In		Ft			In		
Sy: Sloan	0-8	Silty clay	0-0.5	Apparent	Nov-Jun	>60	---	High.
	8-34	Loam, silt loam, cla loam.						
	34-40	Stratified loam to s clay loam						
	40-60	Coarse sa gravelly						
We: Westland	0-16	Silty cla	0-1.0	Apparent	Dec-May	>60	---	High.
	16-42	Clay loam						
	42-46	Gravelly loam, gr sandy lo						
	46-60	Stratifie to grave sand.						
Wn: Whittaker	0-13	Loam	1.0-3.0	Apparent	Jan-Apr	>60	---	High.
	13-38	Clay loam sandy cl loam.						
	38-60	Stratifie coarse s clay.						

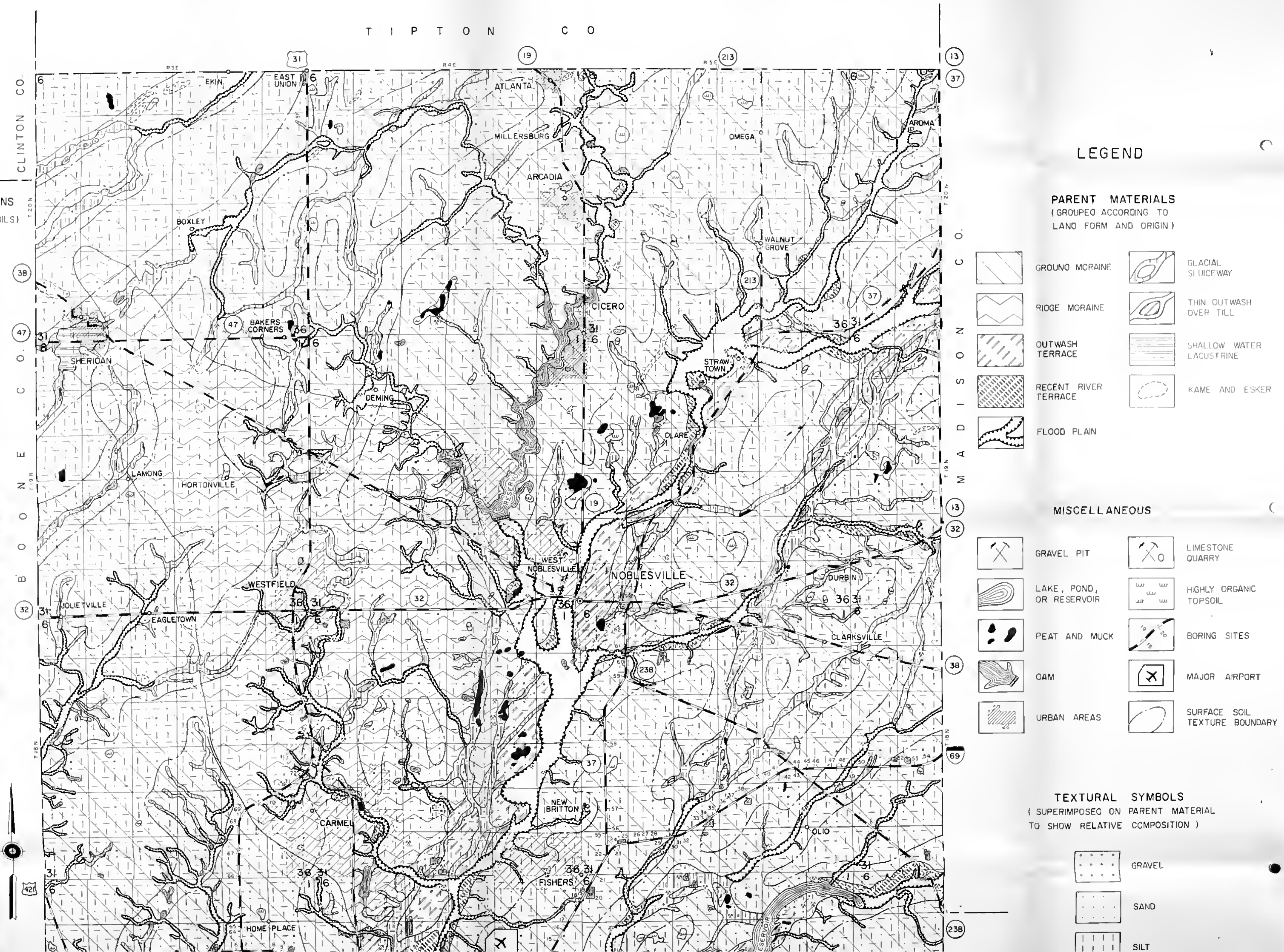
Appendix B – continued

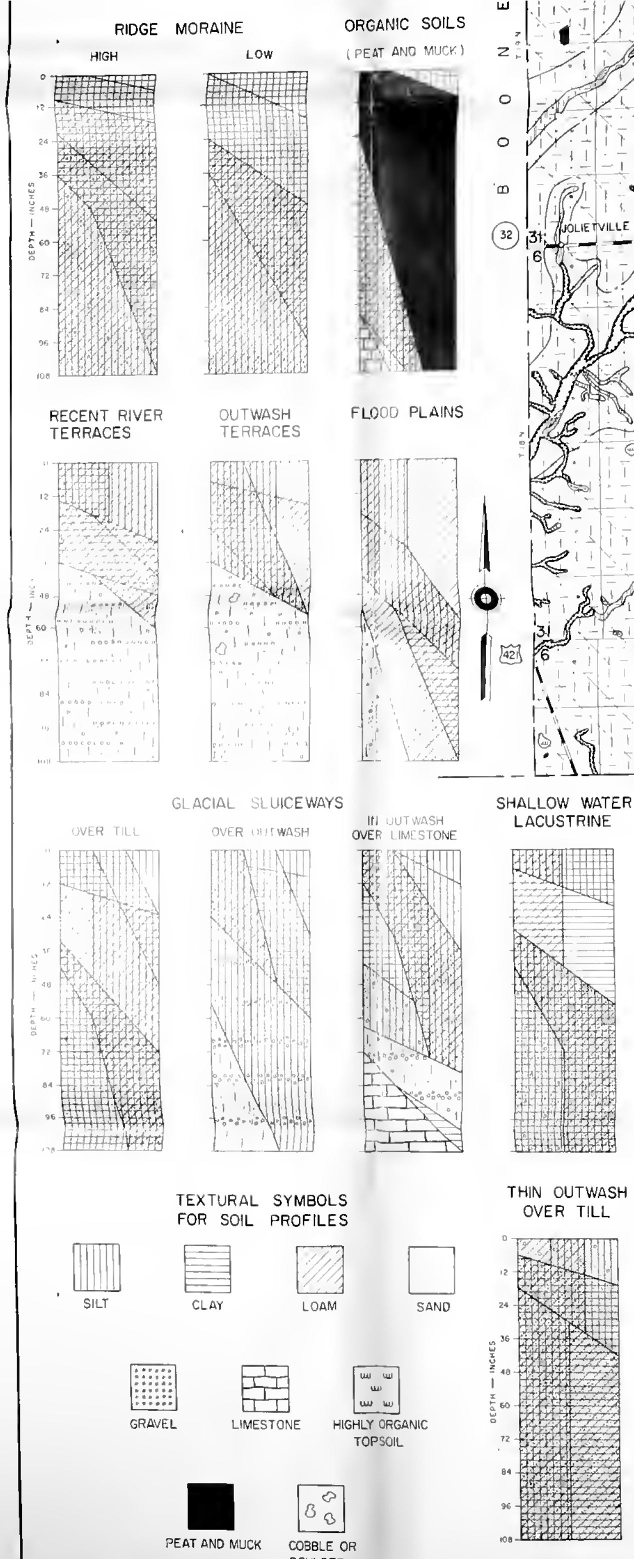
Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number-- 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
[illegible]-------- Sloan	0-8	Silty clay loam	CL	A-6, A-7	0	90-100	85-95	80-95	60-90	35-50	15-30
	8-34	Loam, silty clay loam, clay loam.	CL	A-6, A-7	0	85-95	80-95	65-95	50-85	20-50	10-30
	34-40	Stratified sandy loam to silty clay loam.	CL-ML, CL, ML	A-4, A-5, A-6, A-7	0	85-95	80-95	45-95	35-85	25-45	5-20
	40-60	Coarse sand, gravelly sand.	SP, SP-SM	A-1, A-3	0-5	55-90	50-90	20-60	3-10	---	NP
[illegible]-------- Westland	0-16	Silty clay loam	CL, ML	A-6, A-7	0	100	95-100	90-100	75-90	30-45	10-25
	16-42	Clay loam--------	CL	A-6, A-7	0	95-100	90-100	80-90	65-75	35-50	15-30
	42-46	Gravelly clay loam, gravelly sandy loam.	CL	A-6	0-5	65-75	60-70	55-70	50-70	30-50	15-30
	46-60	Stratified sand to gravelly sand.	SP, GP, SP-SM, GP-GM	A-1	1-5	30-70	22-55	7-20	2-10	---	NP
[illegible]-------- Whitaker	0-13	Loam------------	CL, CL-ML	A-4, A-6	0	100	95-100	90-100	50-90	22-33	4-12
	13-38	Clay loam, loam, sandy clay loam.	CL	A-6, A-7	0	100	95-100	90-100	70-80	30-47	13-26
	38-60	Stratified coarse sand to clay.	CL, SC, ML, SM	A-4	0	98-100	98-100	60-85	40-60	15-25	3-9

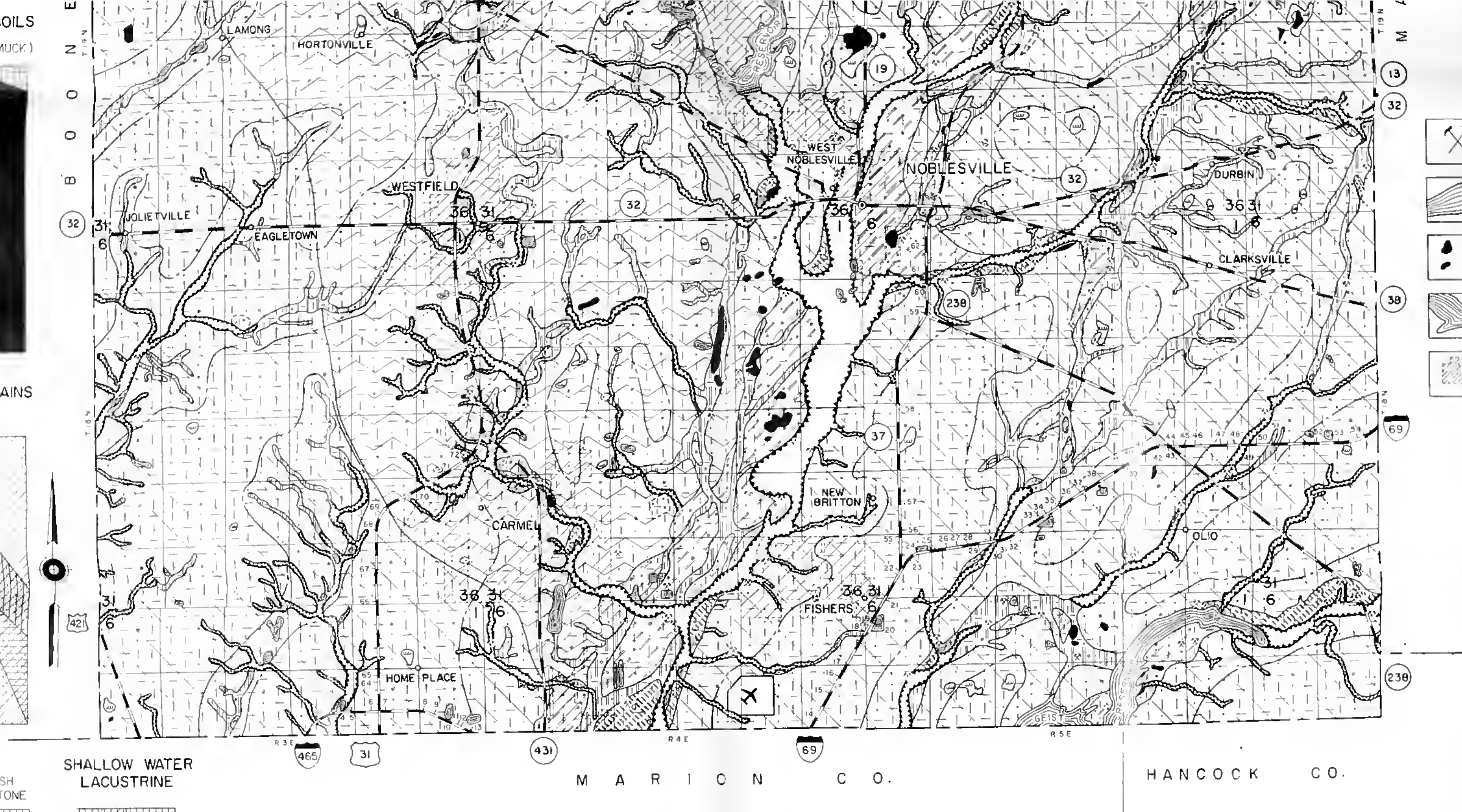
Soil name and map symbol	Depth	Permeability	Shrink-swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	High water table: Depth*	Kind	Months	Bedrock: Depth	Hardness	Potential frost action
	In	In/hr				Ft			In		
Sloan	0-8	0.6-2.0	Moderate	High------	Low-------	0-0.5	Apparent	Nov-Jun	>60	---	High.
	8-34	0.2-2.0	Moderate	High------	Low-------						
	34-40	0.2-2.0	Low--------	High------	Low-------						
	40-60	6.0-20	Low--------	High------	Low-------						
Westland	0-16	0.6-2.0	Moderate	High------	Low-------	0-1.0	Apparent	Dec-May	>60	---	High.
	16-42	0.06-0.2	Moderate	High------	Low-------						
	42-46	0.06-0.2	Moderate	High------	Low-------						
	46-60	>20	Low--------	High------	Low-------						
Whitaker	0-13	0.6-2.0	Low--------	Moderate	Moderate	1.0-3.0	Apparent	Jan-Apr	>60	---	High.
	13-38	0.6-2.0	Moderate	High------	Moderate						
	38-60	0.6-6.0	Low--------	High------	Low-------						

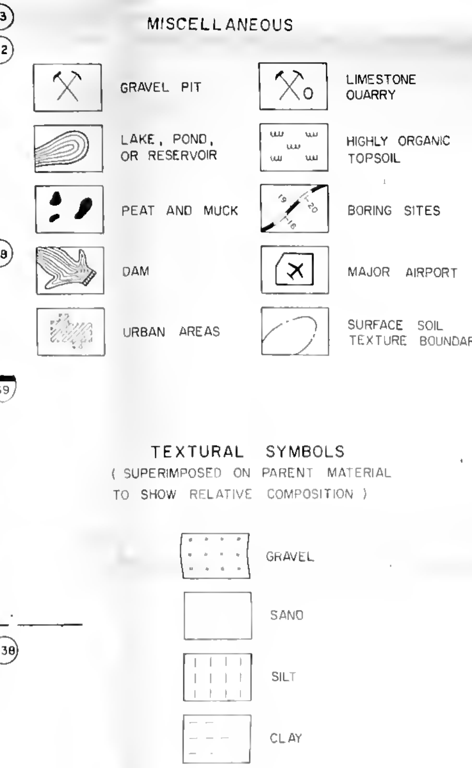
GENERAL SOIL PROFILES











ENGINEERING SOILS MAP

HAMILTON COUNTY

INDIANA

PREPARED FROM

1941 AAA AERIAL PHOTOGRAPHS

BY

JOINT HIGHWAY RESEARCH PROJECT

AT

PURDUE UNIVERSITY

1983

SCALE OF MILES

PREPARED UNDER THE SUPERVISION OF E. M. GEFELL AND R. D. MILES

DRAWN BY E. P. H. CHEN

COVER DESIGN BY ALDO GIORGINI